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OF
NEBRASKA.

VOLUME XXVII, ARTICLE IV.

PORK PRODUCTION.

REPORT OF EXPERIMENTAL SUBSTATION, NORTH PLATTE, NEBRASKA.

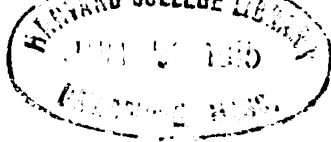
W. P. SNYDER, Superintendent.
E. A. BURNETT, Director.

DISTRIBUTED APRIL 10, 1915.



A GOOD TYPE OF BROOD SOW.

LINCOLN, NEBRASKA
U. S. A.



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PORK PRODUCTION.

BY W. P. SNYDER.*

INTRODUCTION.

This bulletin reports the work done with hogs during the past three years, with summaries of work reported in Bulletins 99, 121, 123, and 124. In order to have the results reported in the various bulletins comparable, we endeavor to assign to grain and to hogs values that would be fairly uniform for the several years. At the time the last bulletins were written, the average price we had paid for corn during the existence of the Substation was 47 cents per bushel and the average price received for hogs was \$5.90 for 100 pounds. Therefore, those prices were used in calculating the results and have been used, except in a few instances, in this bulletin.

The average price paid for corn during the 10 years since the Substation was established is 48.3 cents per bushel. The average price paid for corn during the past three years is 51.3 cents per bushel, and the average price received for hogs during the same period is \$7.04 per 100 pounds. The recent prices give a much larger profit than the former prices. Unless otherwise stated, the prices used in this bulletin are as follows:

Hogs, per 100 pounds.....	\$5.90
Corn, per bushel.....	.47
Wheat, per bushel.....	.70
Barley, per bushel.....	.40
Rye, per bushel	.56
Oil meal, per ton	30.00
Tankage, per ton	40.00
Shorts, per ton	24.00
Alfalfa meal, per ton.....	15.00
Chopped alfalfa, per ton.....	10.00
Alfalfa hay, per ton.....	8.00

* The author is indebted to Mr. B. M. Stackhouse for his efficient help in keeping the records and in compiling the tables.

The cost of alfalfa pasture has not been considered in the majority of the tables but has been mentioned in the discussion in connection with the tables. The cost of the pasture depends upon the size of the hog and on the amount of grain being fed, as well as on many other conditions. We have considered it as 25 cents per month or 0.8 cents per day per hog not being fed grain, or one-half that amount for hogs fed about a full ration of grain. Pigs have been charged less.

Feed other than alfalfa is termed *grain* in the tables. Where chopped alfalfa or alfalfa meal was a part of any ration in the experiment, all the grain was ground. The alfalfa meal was mixed with the grain; the chopped alfalfa was put into the trough and the grain poured over it. The feed was weighed separately for each lot at each feeding time.

The hogs had access to water at all times unless the weather was such that the water froze quickly. During the summer a constant supply of fresh water was furnished in the fields by means of a gravity water system that kept fresh water in cement troughs at all times.

In all experiments the hogs were weighed every second week.

The *mean* weight is the average of the first and last weights in the period or the experiment.

PART I.

WINTERING BROOD SOWS.

EXPERIMENT 30. WINTERING OLD BROOD SOWS.

The following table gives the results of wintering yearling or older brood sows on corn and alfalfa during four successive winters. A herd of 20 sows was divided into two even lots. One lot was fed shelled corn in a trough or on clean ground and a good quality of alfalfa hay in a rack; the other lot was fed a ration of ground corn mixed with an equal weight of chopped alfalfa. During the fourth winter, corn was replaced by wheat. The ground grain and chopped alfalfa were either mixed in the feed house, or the alfalfa put into the trough, the ground grain poured over it, and the whole moistened with water. The sows had the run of small fields sowed to rye in the fall. This furnished some green feed. They were fed in the open, but had warm sleeping quarters.

During the first winter, the plan was to keep the two lots gaining at the same rate. For this reason Lot 91, fed alfalfa hay in a rack, was given more grain than Lot 92. The sows fed alfalfa in the rack required 60 pounds more grain to produce 100 pounds of gain than the sows fed a ration consisting of half grain and half alfalfa. The latter sows ate 305 pounds more alfalfa than the former to produce 100 pounds of gain. It would seem that 60 pounds of corn fed to Lot 91 had the same effect as 305 pounds of alfalfa fed to Lot 92. The 305 pounds of alfalfa cost three times as much as the 60 pounds of corn. Therefore, corn and alfalfa hay in a rack produced cheaper gains than a ration of half ground corn and half chopped alfalfa. The sows fed the mixed ration gained 7.5 pounds more per head than the sows fed alfalfa hay in the rack, but it cost \$1.40 more per head to winter the sows fed half corn and half chopped alfalfa than to winter the other sows. Corn never gets so high in price that the lot fed half alfalfa in this test would have given 100 pounds of gain as cheaply or have been wintered as cheaply as the lot fed corn with alfalfa hay in the rack.

During the second winter, each lot was fed the same amount of corn. The average daily gain per head of the two lots was 0.47 pound as against 0.89 pound the winter previous, tho

more grain was fed during the second winter. We attribute the slow gain to the very severe winter. All stock made much slower gains for the feed eaten than during previous winters. In a climate where severe winters are usual, the severity of the weather could be largely overcome by better protection. On account of the very slow gain made by the sows fed alfalfa in the rack, 100 pounds of gain in this lot cost slightly more than in the other lot, but the cost of wintering was much less. Tho the same amount of corn was eaten by each lot, yet the sows fed half corn and half alfalfa ate so much more alfalfa than the other sows that the cost of wintering them was \$2.39 more per head. The additional gain of 25 pounds on the sows fed half corn and



Fig. 1.—Old sows on alfalfa pasture. No grain when not suckling pigs.

half chopped alfalfa cost \$2.39. It seems to be apparent that corn with alfalfa in the rack was a better ration in this test than half ground corn and half chopped alfalfa. It might have been more profitable to have fed both lots more grain so as to have secured more gain during the winter.

During the third winter the sows fed half ground corn and half chopped alfalfa were given only 75 per cent as much corn as the lot fed shelled corn with the alfalfa hay in the rack. The weather conditions were favorable. The sows were fed only about 10 per cent more grain per 100 pounds of their weight than during the previous winter, but gained more than twice as much during the previous winter. The lot fed half corn and half alfalfa during this winter received less feed per 100 pounds of their weight than during the previous winter but gained nearly twice as much. We can account for this difference in gain only by the

difference in the weather. During the third winter the cost of wintering the sows on half corn and half alfalfa was \$1.01 more than on a ration containing about one-third more corn with alfalfa hay in the rack. The cost of 100 pounds of gain in the former lot was \$1.63 more than in the latter lot. The gain per sow was 20 pounds greater from the corn and alfalfa in the rack than from the other ration. The results of this winter accord with the results of the two preceding winters, indicating that a ration of one-half ground corn and one-half chopped alfalfa is not as satisfactory as a ration of corn with alfalfa in a rack for wintering old brood sows.

In the winter of 1913-1914 wheat was fed instead of corn. The one lot of sows was fed ground wheat in a trough and alfalfa hay in a rack; the other lot was fed the same amount of ground wheat as the former lot and with it an equal weight of chopped alfalfa and also alfalfa hay in a rack. The rate of gain on the sows in the two lots was almost equal and the amount of grain required to produce 100 pounds of gain was nearly the same. But the sows that got the grain unmixed with alfalfa ate 200 pounds of alfalfa per head during the four months, while the sows that were fed a ration of half grain and half alfalfa ate 527 pounds of alfalfa per head. The cost of feed for 100 pounds of gain where the alfalfa was all fed in a rack was \$6.51 but where the alfalfa was chopped and mixed with the grain the cost was \$8.36. The cost of wintering a sow on grain in the trough and alfalfa in the rack was \$6.30. The cost of wintering a sow on a ration of half grain and half alfalfa was \$8.02. The gain on the two lots was almost equal. The ration of half grain and half alfalfa was not as satisfactory as the ration of about the same amount of grain with alfalfa hay in a rack.

It is probable that half alfalfa is too great a proportion for feeding to hogs even for keeping them thru the winter when little or no gain in weight is desired. When hogs eat alfalfa from a rack it is very important that the alfalfa be of the best quality.

The average of these four tests shows that it required 9.9 bushels of corn and 86 pounds of alfalfa hay or 8.84 bushels of corn and 495 pounds of chopped alfalfa, to keep a sow, weighing 387 pounds, thru the winter and increase her weight about 95 pounds. The length of time included was 121 days, or four months. The cost per day of feed for a sow was about 5 cents. The daily gain in weight per sow was 0.78 pound. If hogs had been worth \$6.43 per 100 pounds and corn 47 cents per bushel the value of the increase in weight would have balanced the cost of the feed.

TABLE 1.—*Wintering old brood sows. Record of four winters—1910-1914.*
EXPERIMENT 30.

Date	November 1, 1910 February 28, 1911		November 14, 1911 March 5, 1912		November 4, 1912 March 18, 1913		November 4, 1913 March 10, 1914		Average 4 years	
	91	92	93	94	95	96	97	98	S. C. A. H.	Gr. C. Ch. A.
Lot No.										
Ration*	90% S. C. 50% Gr. C. 10% A. H. 50% Ch. A.				93% S. C. 50% Gr. C. 7% A. H. 50% Ch. A.		71% W. 29% A. H.	48% W. 48% C. A. 4% A. H.		
No. sows in lot	10	10	10	10	11	11	11	11	10	10
No. days in experiment	112	112	113	113	134	134	126	126	121	121
Average first weight per sow, lbs.	339.5	363.5	353	344	333.6	315	339	336.4	341.3	337
Average last weight per sow, lbs.	436	457.5	394	410	472.7	434.8	435.9	431.3	434.6	433.4
Average gain per sow, lbs.	96.5	104.92	41	66.58	139.1	119.8	96.9	95.9	93.3	96.4
Average daily gain per sow, lbs.	413	353	1,254	785	563	486	489	494	680	530
Lbs. grain for 100 lbs. gain	44	353	1,110	785	602	490	200	527	100	539
Lbs. alfalfa for 100 lbs. gain	481	353	1,364	1,570.52	602	976	689	1,021	760	1,009
Cost of feed for 100 lbs. gain	\$3.66	\$4.74	\$10.97	\$8.81	\$4.90	\$7.53	\$6.51	\$8.36	\$6.50	\$7.54
Cost of feed for wintering sow	3.53	4.93	4.50	6.89	8.91	7.82	6.30	8.02	5.29	6.92
Value of gain on sow at \$5.00	2.06†	0.91†	2.42	3.89	3.91	7.77	5.72	5.66	5.20	5.97
Net cost of feed for wintering sow	2.06†	0.91†	2.08	3.00	1.40†	1.77	0.58	2.36	0.21	3.65
Lbs. alfalfa fed daily per sow	3.16	3.29	4.53	4.33	5.85	4.73	3.76	3.76	4.43	4.05
Lbs. alfalfa fed daily per sow	4.10	3.29	4.00	4.33	4.44	4.38	1.54	4.01	4.70	4.05
Lbs. grain fed daily per sow	3.97	6.58	4.95	9.10	6.29	8.72	5.30	7.77	5.13	8.04
Lbs. grain fed daily per 100 lbs. weight of sow	90	81	1.22	1.20	1.45	1.16	.94	.98	1.13	1.04
Lbs. feed fed daily per 100 lbs. weight of sow	1.02	1.02	1.32	2.40	1.56	2.33	1.37	2.03	1.32	2.09
Bushels grain fed during winter per sow	7.12	6.56	9.19	9.19	14.0	10.3	7.89†	7.89†	9.90	8.84
Lbs. alfalfa fed during winter per sow	46	367	45	518	60	588	195	506	86	495
Average mean weight per sow lbs.	387.8	405.5	373.5	377	403.2	374.9	387.5	383.4	398	385.2

* S. C., shelled corn; Gr. C., ground corn; W., wheat; A. H., alfalfa hay; Ch. A., chopped alfalfa.

† Profit above cost of feed for wintering sow.

‡ Bushels of wheat 1913-14, but reduced to bushels of corn in the last two columns (4-year average).

Table 1, combining the results of the four winter experiments, shows that the average gain was almost the same for the sows of each lot. The cost of feed for 100 pounds of gain from half ground grain and half chopped alfalfa was \$1.04 more than from the other rations, and the cost of wintering a sow on this ration was \$1.63 more than on the ration of grain with alfalfa in a rack. In these four tests, feeding a very light grain ration and letting the sows eat alfalfa at will from a rack proved a better practice than mixing the grain and chopped alfalfa in equal proportions and thereby compelling the sows to eat a pound of alfalfa with each pound of grain.

EXPERIMENT 31. WINTERING YOUNG BROOD SOWS.

The following table gives the record of wintering gilts during five years when the ration contained one part of chopped alfalfa



Fig. 2.—Gilts near farrowing. Wintered on grain and alfalfa.

mixed with from two to three parts of grain. The gilts were fed all they cared to eat of the mixture. When there was some indication that they were becoming too fleshy, the percentage of alfalfa to grain was increased. They were always in rather heavy flesh at the time of farrowing and produced rather large litters of healthy pigs.

The gilts were farrowed during the latter part of March or in April and were fed a medium grain ration during the summer while grazing on alfalfa pasture. Their summer records are shown under the numbers shown in the footnote.* At no time were the gilts given a full grain ration.

* Record of gilts, summer of 1909, Bulletin 121, Lot 37; 1910, present bulletin, Lot 100; 1911, present bulletin, Lot 101; 1912, present bulletin, Lot 102; 1913, present bulletin, Lot 103.

When the winter feeding period began, about November 10, the average weight of the gilts was 178 pounds. During the winter the average daily gain per gilt was 0.91 pound. The winter period was closed shortly before the first gilt farrowed. This ranged from March 14 to April 1. At that time the average weight was 301 pounds per gilt.

There were required on the average 477 pounds of grain and 181 pounds of alfalfa to produce 100 pounds of gain. At the prices assumed in this bulletin the average cost of grain and alfalfa eaten in producing 100 pounds of gain was \$5.30.

The average amount of grain fed daily per 100 pounds weight of hog was 1.63. This is too light a grain ration to produce fast or cheap gains. The alfalfa increased this to 2.48 pounds, which is still too light a ration for the most profitable results when fattening hogs. However, this ration gave the hogs as much bulk as they would eat, which may be an advantage, and brought them forward to the time of farrowing sufficiently fast and in a high enough condition of flesh.

That no trouble occurred at the time of farrowing and that fairly large, healthy litters were farrowed is an indication that the ration has some merit. A smaller percentage of alfalfa probably would have given cheaper as well as faster gains but would have made the gilts too fleshy unless the amount fed had been kept considerably below a full feed.

The feed eaten by the average gilt during the four and one-half months was equal in value to 13.5 bushels of corn. It cost a few cents more to winter a gilt than an old sow, as these hogs were wintered, but the period for the gilts was two weeks longer and also the gain per head was greater than with the old sows. The net cost of wintering the gilt was less than that of wintering the old sow, since the gilt made more gain than the old sow for the feed eaten. Slow gains are usually more expensive than fast gains. The value of the sow ready to farrow in the spring above the value of the unbred sow of the same weight in the fall should be considered when studying the cost of gains made on sows while being wintered.

TABLE 2.—Wintering young brood sows. Record of five winters—1909-1914.

EXPERIMENT 31.

Year	1909-1910	1910-1911	1911-1912	1912-1913	1913-1914	Average
Date	Nov. 9 March 15	Nov. 8 March 14	Nov. 14 March 19	Nov. 4 April 1	Nov. 4 March 25	5 years
Lot No.	37	100	101	102	103	
Ration *	C. B. Ch. A.	C. B. R. W. Ch. A.	C. S. Ch. A.	C. Ch. A.	W. Ch. A. A. H.	
No. sows in lot	25	25	25	20	25	24
No. days in experiment	126	126	126	148	141	133
Average first weight per sow, lbs.	155.6	201.2	188.4	181	165.8	178.4
Average last weight per sow, lbs.	276.4	322.8	276	311.4	318.4	301
Average gain per sow, lbs.	120.8	121.6	87.6	130.4	152.6	122.6
Average daily gain per sow, lbs.	.95	.97	.695	.88	1.08	.91
Lbs. grain for 100 lbs. gain	430	412	585	534	426	477
Lbs. alfalfa for 100 lbs. gain	138	193	240	180	153	181
Lbs. feed for 100 lbs. gain	568	605	825	714	579	658
Cost of feed for 100 lbs. gain	\$4.30	\$4.97	\$6.12	\$5.38	\$5.73	\$5.30
Cost of feed for wintering sow	5.20	6.04	5.36	7.02	8.74	6.47
Value of gain on sow at \$5.90	7.13	7.17	5.17	7.69	9.00	7.23
Profit on sow above cost of feed	1.93	1.13	.19†	.67	.26	.76
Lbs. grain fed daily per sow	4.12	3.98	4.07	4.69	4.61	4.29
Lbs. alfalfa fed daily per sow	1.28	2.01	1.64	1.60	1.66	1.64
Lbs. feed fed daily per sow	5.40	5.99	5.71	6.29	6.27	5.93
Lbs. grain fed daily per 100 lbs. wt. of sow	1.90	1.52	1.75	1.90	1.09	1.63
Lbs. feed fed daily per 100 lbs. wt. of sow	2.52	2.28	2.46	2.55	2.59	2.48
Lbs. grain fed during winter, per sow	519	501	513	694	650	575
Lbs. alfalfa fed during winter, per sow	161	253	207	237	234	218
Average mean weight of sow, lbs.	216	262	232.2	246.2	242.1	239.7

* C., corn; B., barley; Ch. A., chopped alfalfa; W., wheat; S., silage; A. H., alfalfa hay.

† Net cost of feed for wintering sow.

PART II.**COST OF THE 50-POUND PIG.**

In the following discussion and tables we show the cost of the feed used in producing the average 50-pound pig raised on the Substation during the past four years, together with data on other factors entering into the raising of pigs.

There are various ways of calculating the results. We have found it difficult to get an accurate record of the sow from the time she weaned a spring litter until she went into winter quarters that fall. We met with this difficulty because some sows were sent to market, some raised fall litters, and some were kept over without raising fall litters.



Fig. 3.—The 50-pound pig. Cost of feed about \$2.

In a former bulletin we endeavored to give the record on the sow for a complete year, or from the time she weaned one spring litter until she weaned the next spring litter. We had the record on the gilts extend from about August 1 of their first year until one year later.

In the present bulletin we are leaving out of the record of the old sows the time between the weaning of a spring litter and the date the sows were put into winter quarters. We are, therefore, giving the record of the old sows from the time they went into winter quarters until their pigs were weaned and had reached the average weight of 50 pounds. In order to have the record of the old sows and the record of the young sows fairly comparable, we are giving the record on the young sows from the time they went into winter quarters until their litters were weaned and had reached the average weight of 50 pounds.

All feed eaten by the sow during the time indicated above and all feed eaten by the pigs until their average weight was 50 pounds each is charged to the sow. She is credited with the gain made in her weight between the time she went into winter quarters and the time her pigs reached the 50-pound weight. She is also credited with the total weight of her pigs when their average weight was 50 pounds.

There is no account taken of any cost except that of feed. Labor, interest on investment, and risk—excepting the risk on young pigs—are not taken into account. These figures are intended to give the cost of the feed used in producing a 50-pound pig.

The old sows were wintered on a ration of corn with alfalfa hay in a rack or on a ration of one-half ground corn and one-half chopped alfalfa. This is given in detail under the heading "Wintering Old Brood Sows." The young sows were wintered on a ration of three-fourths corn, or corn and other grains, and one-fourth alfalfa. This is given in detail under the heading "Wintering Young Brood Sows." While suckling the pigs, all sows were usually fed a liberal ration of grain, alfalfa, and some mill feeds. They were in alfalfa fields after the pigs were a few weeks old. The pigs were fed corn as soon as they cared to eat.

In order to compare the cost of producing the spring pig and the fall pig, we have given the results obtained by considering the period beginning just before the sow farrowed and ending when her pigs were weaned and had reached the 50-pound weight. In this comparison the period covered is the same for the spring as for the fall litters.

EXPERIMENT 32. PIGS FROM OLD SOWS.

In Table 3 we give in detail the record for an average of 18 sows per winter for four winters. They were carried thru the winter on corn and alfalfa, as has been stated. The average gain on the sows from fall until they farrowed in the spring was 125 pounds. They lost about half of this gain while farrowing and suckling the litters but weighed an average of 62 pounds more when the pigs were weaned than when they went into winter quarters the previous fall. These 62 pounds are credited to the sows at \$5.90 per 100 pounds.

The average cost* of the feed per sow from fall until she farrowed was \$6.98, or the equivalent of 11.52 bushels of corn at 47 cents per bushel. The average cost of the feed eaten by the sow from the time she farrowed until her pigs were weaned, and

* For price of feed, see page 5.

of the feed eaten by the pigs until their average weight was 50 pounds each, was \$10.43. The average cost of all the feed used by the sow and her litter was \$17.41. The value of the 62 pounds gain on the sow reduced this to a net cost of \$13.76. This is the net cost of the feed used in producing the litter to the average weight of 50 pounds per pig.

An average of 11.1 pigs was farrowed per sow. The average weight of each pig at birth was 2.4 pounds. When the average weight of the pigs was 50 pounds each, then the average number of pigs per litter was only 6.55. From the date of being farrowed until the 50-pound weight was reached, the pigs gained at the rate of 0.53 pound each daily and reached the 50-pound weight when 89 days old.

The average cost of the feed used in producing the 50-pound pig as here calculated is \$2.11.

TABLE 3.—*Cost of feed for producing a 50-pound pig from old sows. Four years' record—1910-1913.*

EXPERIMENT 32.

Year.....	1910	1911	1912	1913	Av'rage
No. sows in lot	20	20	14	18	18
Weight per sow in fall, Nov. 10, lbs.	322	346.5	330	324	330.6
Gain per sow during winter, lbs.	111	126.5	120	142	124.9
Weight per sow at farrowing time, lbs.	433	473	450	466	455.5
Weight per sow at weaning time, lbs.	383	363.2	426	397.5	392.4
Loss per sow while suckling, lbs. ...	50	109.8	24	68.5	63.1
Gain per sow during experiment, lbs.	61	16.7	96	73.5	61.8
Grain eaten per sow before farrowing, bu.	9.62	10.47	12.5	13.5	11.52
Grain eaten per sow and litter after farrowing, bu.	22.04	18.77	24.3	17.3	20.6
Cost of winter grain per sow	\$4.52	\$4.92	\$5.88	\$6.35	\$5.42
Cost of winter alfalfa per sow	1.60	1.17	1.71	1.74	1.56
Cost of grain per sow and litter after farrowing and until pigs average 50 lbs. each	10.36	8.83	11.42	8.13	9.68
Cost of summer pasture until average weight of pig was 50 pounds..	.75	.75	.75	.75	.75
Total cost of feed for sow and litter	17.23	15.67	19.76	16.97	17.41
Value of gain on sow at \$5.90 per 100 lbs.	3.60	.99	5.66	4.34	3.65
Net cost of feed for sow and litter..	13.63	14.68	14.10	12.63	13.76
No. of pigs farrowed per sow.	10.07	12.2	10.4	11.3	11.1
Av. weight of pigs when farrowed, lbs.	2.32	2.46	2.14	2.7	2.4
Av. age of pigs when 50-pound wt. reached, in days.	91	90	89	87	89
Average daily gain per pig, lbs.	.52	.528	.54	.52	.53
No. of pigs raised per sow	7	6.9	6.6	5.7	6.55
Cost of 50-pound pig	\$1.95	\$2.13	\$2.13	\$2.22	\$2.11

EXPERIMENT 33. PIGS FROM YOUNG SOWS.

In Table 4 we give similar data on young sows. The gilts gained an average of 149 pounds each during the winter at a cost of \$7.28 for feed. This gave an average net profit of \$1.59 per head above cost of feed, considering corn worth 47 cents per bushel. They ate during the winter the equivalent in value of 12.72 bushels of corn per head. The cost of the feed eaten by the average sow, from the time she farrowed until her pigs were weaned, and by the pigs, until their average weight was 50 pounds each, was \$8.46; or the cost of all feed for sow and litter from fall until the average pig weighed 50 pounds was \$16.41. The average increase in weight of the sow during the experiment was 101.4 pounds. This at \$5.90 per 100 pounds reduced the cost of feed to a net cost of \$10.43 per sow and litter.

TABLE 4.—*Cost of feed for producing a 50-pound pig from young sows. Four years' record—1910-1913.*

EXPERIMENT 33.

Year.	1910	1911	1912	1913	Av'rage
Number of sows in lot	25	25	22	15	21
Weight per sow in fall, Nov. 10, lbs.	156	201	188	181	181.5
Gain per sow during winter, lbs.	164	159	112	159.8	148.7
Weight per sow at farrowing time, lbs.	320	360	300	340.8	330.2
Weight per sow at weaning time, lbs.	281	275	270	305.5	282.9
Loss per sow while suckling, lbs.	39	85	30	35.3	47.3
Gain per sow during experiment, lbs.	125	74	82	124.5	101.4
Grain eaten per sow before farrowing, bu.	13.11	13.5	10.27	14.0	12.72
Grain eaten by sow and litter after farrowing, bu.	19.05	17.2	16.0	19.7	17.99
Cost of winter grain, per sow.	\$6.16	\$6.34	\$4.82	\$6.58	\$5.98
Cost of winter alfalfa, per sow.	.99	1.47	1.13	1.32	1.22
Cost of grain per sow and litter after farrowing and until pigs average 50 lbs. each	8.96	8.08	7.52	9.26	8.46
Cost of summer pasture until average weight of pig was 50 lbs.	.75	.75	.75	.75	.75
Total cost of feed for sow and litter.	16.86	16.64	14.22	17.91	16.41
Value of gain on sow at \$5.90 per 100 lbs.	7.37	4.37	4.84	7.38	5.98
Net cost of feed for sow and litter. .	9.49	12.27	9.38	10.53	10.43
Number of pigs farrowed per sow. .	8	8.6	7.8	8.5	8.2
Av. weight of pigs when farrowed. .	2.31	2.4	2.02	2.5	2.31
Av. age of pigs when 50-lb. weight reached, in days.	101	108	96	90	99
Average daily gain per pig, lbs.	.49	.46	.52	.53	.50
Number of pigs raised per sow. .	6.5	6.9	5.3	6.2	6.2
Cost of 50-lb. pig	\$1.46	\$1.78	\$1.77	\$1.70	\$1.68

The average sow farrowed 8.2 pigs weighing 2.31 pounds each at birth. When the average weight of 50 pounds was reached, the number had decreased to 6.2. From the date of being farrowed until the 50-pound weight was reached, the average pig gained at the rate of one-half pound daily and reached the 50-pound weight when 99 days old.

According to this record and this method of calculation, the cost of feed used in producing the average 50-pound pig from the young sow was \$1.68.

EXPERIMENT 34. FALL PIGS.

COST OF FALL AND SPRING PIGS COMPARED.

In comparing the cost of the feed eaten in producing a 50-pound pig in the fall with the cost of the feed eaten in producing a similar pig in the spring, we are able to consider only a short period. In this comparison we are considering only the period beginning just before the sow farrowed and ending when the average weight of the pigs was 50 pounds each.

The fall pigs came after the middle of September and before the middle of October. They had alfalfa pasture until the alfalfa was frozen. The pasture has little value after October 20 of the usual fall. The care and feed were the same in the fall as in the spring.

Table 5 gives the records of the old sows and young sows in the spring and of the old sows in the fall for four years. In the final average there are 579 spring pigs from old sows, 543 spring pigs from young sows, and 153 fall pigs from old sows.

The young sows ate less feed in producing the 50-pound pig than old sows. They raised nearly as many pigs and grew them to the 50-pound weight nearly as quickly as the old sows. The young sow was more efficient than the old sow in these tests. In the record of the short period, the average cost of feed to produce the 50-pound spring pig of the old sow was \$2.05, and the young sow \$1.81.

In comparing the average cost of the feed used in producing the 50-pound pig in the spring with the average cost of the feed used in producing the 50-pound pig in the fall, we find that in these tests more feed was used in the fall than in the spring. This is probably on account of the fact that the fall pigs were on pasture a shorter time than were the spring pigs. To offset the greater cost of feed for the fall pigs, the sows farrowing in the fall suffered a smaller loss in weight than did the sows that farrowed in the spring. This made the total charge against the spring litter greater than that against the fall litter. There was

TABLE 3.--A comparison of the cost of pigs from old sows and young sows and of spring pigs and fall pigs.*

EXPERIMENT 34.

Year	No. sows in test	Cost of feed after farrowing till 50-lb. wt. reached	Loss of wt. on sow between last wt. before farrowing and date of weaning, lbs.	Value of loss of wt. on sow at \$5.90 per 100 wt.	Total charge against pigs	No. of pigs raised	Cost of 50-lb. pig
OLD SOWS. SPRING LITTERS.							
1910.	20	\$10.36	50	\$2.95	\$13.31	7.0	\$1.90
1911.	20	8.83	110	6.49	15.32	6.9	2.22
1912.	14	11.42	24	1.42	12.84	6.6	1.95
1913.	18	8.13	68.5	4.04	12.17	5.7	2.14
Av.	18	9.68	63.1	3.73	13.41	6.5	2.05
YOUNG SOWS. SPRING LITTERS.							
1910.	25	8.96	39	2.30	11.26	6.5	1.73
1911.	25	8.08	85	5.02	13.10	6.9	1.90
1912.	22	7.52	30	1.77	9.29	5.3	1.75
1913.	15	9.26	35.3	2.08	11.34	6.2	1.83
Av.	21	8.46	47.3	2.79	11.25	6.2	1.81
OLD SOWS. FALL LITTERS.							
1910.	7	6.94	33	1.95	8.89	4.8	1.85
1911.	9	11.28	17	1.00	12.28	5.9	2.08
1912.	5	13.07	21	1.24	14.31	7.0	2.04
1913.	5	11.50	36	2.12	13.62	6.4	2.13
Av.	6	10.70	26.7	1.58	12.28	6.0	2.03

* In this table the feed record begins at the time the pig was farrowed and ends when the average weight was 50 pounds.

an average of one-half pig more per sow raised in the spring than in the fall. The final average total cost of the feed used in producing the 50-pound pig is practically the same in the fall as in the spring. The cost is given as \$2.05 for the spring pig and \$2.03 for the fall pig. The cost of the fall pig in 1910 seems rather low in the light of the results of the later years. If the results of 1910 were raised to the average of the three years following, the cost of the fall pig would be \$2.08.

These results indicate pretty strongly that under western Nebraska conditions the fall pig may be grown from the time it is farrowed until it weighs 50 pounds as cheaply as the spring pig during the same period of its life.

OLD VS. YOUNG SOWS.

COST OF PIGS FROM OLD SOWS AND YOUNG SOWS COMPARED.

It has not been our purpose to determine the advisability of keeping old or young sows, but the records here given throw some light on this problem. It is our practice to put on the market each summer the sows that did not give satisfactory returns or do not give promise of good results later. This should give assurance that the old sows were equally as promising individuals as the young sows.

The records of these herds during four years indicate that pigs are produced cheaper from young than from old sows. The average net cost of the feed used in producing the 50-pound pig from the old sows, as here indicated, was \$2.10 and from the young sow \$1.68. The old sows farrowed larger litters than the young sows, probably because the unprolific sows had been culled out of the old herd and not out of the young herd, but the old sows raised less than one-half pig per litter more than the young sows. The pigs from the old sows weighed a little more at birth and gained slightly faster than the pigs from the young sows. But the old sows excelled the young sows so slightly in these respects that the young sows were able to overcome these advantages of the old sows in other ways. The average net cost of all feed for the young sow and her litter was \$10.43 and for the old sow and her litter, \$13.76. The increase in weight on the young sows was greater than on the old sows, tho the feed for the former cost less than for the latter. If old sows produce pigs as cheaply as young sows, they must raise enough more pigs than the young sows to balance the extra net expense of keeping them. They did not do this in these tests. It would seem that choosing sows on account of the number of pigs raised is a better practice than making the number of pigs farrowed the standard of promotion.

PART III.

**THE COST OF GROWING PIGS ON ALFALFA PASTURE
AND GRAIN.**

We have the records of the grain fed to and the gains made by spring pigs running in alfalfa pastures and fed various amounts of grain during the past 10 years. The results secured from 1904 to 1910 inclusive are given in detail in Bulletin 121. The cost of gains has varied with the size of the pigs, the amount and kind of grain, and with the seasons; during some summers the pigs have made better gains on the same amount of feed than during other summers.

In this bulletin we have charged the pigs for alfalfa pasture according to the amount of grain fed, since pigs getting a full grain ration eat less alfalfa than similar pigs getting only a light grain ration. The charge made is as follows: 0.6 cent per head daily where a 0.5* per cent ration of grain was fed, 0.5 cent daily where a 1 per cent ration of grain was fed, 0.4 cent daily where a 2 per cent ration of grain was fed, and 0.3 cent daily where a full feed was given. When this charge is made, the cheapest gain is not always that made largely from alfalfa pasture.

EXPERIMENT 35. RECORD OF PIGS DURING SUMMER OF 1911.

During the summer of 1911 we kept an accurate record of five lots of pigs running in alfalfa pastures and fed a medium ration of corn. There were 202 pigs in the five lots. The average amount of corn fed daily per 100 pounds weight of the pigs was 2.75 pounds. The average daily gain per pig was 0.72 pound. There were required 355 pounds of corn for 100 pounds of gain. This grain at 47 cents per bushel cost \$2.98 per 100 pounds of gain. The total cost of grain and alfalfa pasture per 100 pounds of gain was \$3.54. One bushel of corn with alfalfa pasture made 15.9 pounds of gain. The record of this summer is given in detail in Table 6.

* A 0.5 per cent ration is 0.5 pound of grain daily per 100 pounds weight of the pig.

TABLE 6.—*Cost of gains on grain and alfalfa pasture. Record of pigs during summer of 1911.*

EXPERIMENT 35.

Lot No.	104	105	106	107	108
Date	June 28 Sept. 4	Aug. 10 Oct. 31	Aug 9 Nov. 14	Aug. 10 Oct. 31	Aug. 10 Oct. 31
Ration (alfalfa pasture).	Corn	Corn	Corn	Corn	Corn
No. pigs in lot	64	45	25	33	35
No. days in experiment.	68	82	97	82	82
Av. first weight per pig, lbs..	55.6	51.8	74.8	77.4	63.0
Av. last weight per pig, lbs..	111.5	104.1	158.0	130.3	117.8
Av. gain per pig, lbs.	55.9	52.3	83.2	52.9	54.8
Av. daily gain per pig, lbs. .	.82	.64	.857	.645	.668
Lbs. grain for 100 lbs. gain.	319	342	407	349	358
Cost of grain for 100 lbs. gain.	\$2.68	\$2.87	\$3.42	\$2.93	\$3.01
Profit on 100 lbs. gain.	3.22	3.03	2.48	2.97	2.89
Profit per pig	1.80	1.58	2.06	1.57	1.58
Profit per pig daily	.026	.019	.021	.019	.019
Grain fed daily per pig, lbs..	2.62	2 18	3.49	2.25	2.39
Grain fed daily per 100 lbs. weight of pig	3.14	2.79	3.00	2.17	2.64
Av. mean weight of pig, lbs.	83.5	77.9	116.4	103.8	90.4
Price received per bu. grain.	\$1.03	\$0.967	\$0.82	\$0.95	\$0.92
Cost of 100 lbs. gain, in- cluding pasture	3.16	3.50	3.88	3.55	3.60

EXPERIMENT 36. RECORD OF PIGS DURING SUMMER OF 1912.

During the summer of 1912 an accurate record was kept of the grain fed to and the gains made by six lots of 25 pigs each. This record covers the period from July 15 to October 16. Three lots were fed corn, and two lots were fed corn and shorts. The average amount of grain fed daily per 100 pounds weight of the pigs was 2.12 pounds. The average daily gain per pig was 0.51 pound. There were 313 pounds of grain eaten to produce 100 pounds of gain. This grain cost \$2.79 for 100 pounds of gain. The charge for alfalfa pasture raises the cost of feed used in producing 100 pounds of gain to \$3.57. One bushel of grain (56 pounds) with the alfalfa pasture made 17.8 pounds of gain on the hogs. Table 7 gives the results in detail.

EXPERIMENT 37. CORN COMPARED WITH CORN AND SHORTS FOR GROWING PIGS GRAZING ON ALFALFA PASTURE.

Lots 109, 110, and 111, and Lots 112 and 113 give a comparison of the results of feeding pigs a grain ration of corn or of corn and

shorts when grazing on alfalfa pasture. Lots 109, 110, and 111 were similar and were handled in the same manner excepting that Lot 109 was fed a ration of three-fourths corn and one-fourth shorts while Lots 110 and 111 were fed corn only. The rates of gain and the amounts of grain eaten in making 100 pounds of gain was the same in Lot 109, fed corn and shorts, and Lot 111, fed corn. Lot 110, fed corn, made faster and cheaper gains than either of the other lots. As shorts cost more per pound than corn, the pigs fed corn made cheaper gains than those fed corn and shorts.

TABLE 7.—*Cost of gains on grain and alfalfa pasture. Record of pigs during summer of 1912. July 15 to October 16—92 days.*

EXPERIMENTS 36 AND 37.

Lot No.	109	110	111	112	113
Ration	$\frac{3}{4}$ Corn $\frac{1}{4}$ Shorts	Corn	Corn	Corn	$\frac{1}{2}$ Corn $\frac{1}{2}$ Shorts
No. pigs in lot.	25	25	25	25	25
Av. first weight per pig, lbs.	45.2	44.6	47	62	61.2
Av. last weight per pig, lbs.	91.7	96.2	93.5	105.7	109.9
Av. gain per pig, lbs.	46.5	51.6	46.5	43.7	48.7
Av. daily gain per pig, lbs.	.50	.56	.50	.47	.53
Grain for 100 lbs. gain, lbs.	303	273	303	362	325
Cost of grain for 100 lbs. gain	\$2.81	\$2.29	\$2.55	\$3.04	\$3.30
Profit on 100 lbs. gain	3.09	3.61	3.35	2.86	2.60
Profit per pig	1.44	1.86	1.56	1.25	1.27
Profit per pig daily	.015	.02	.017	.013	.014
Grain fed daily per pig, lbs.	1.53	1.53	1.53	1.71	1.71
Grain fed daily per 100 lbs. weight of pig.	2.23	2.17	2.17	2.03	2.00
Average mean weight of pig, lbs.	68.5	70.4	70.3	83.9	85.6
Price received per bushel grain	\$0.97	\$1.20	\$1.09	\$0.91	\$0.84
Cost of 100 lbs. gain, including pas- ture	3.60	3.00	3.34	3.88	4.05

Lot 112 was fed corn and Lot 113 was fed half corn and half shorts. In this comparison the ration of corn and shorts gave a little faster gain with less grain for 100 pounds of gain than the ration of corn. But the higher cost of the shorts made the cost of gains from corn and shorts higher than from corn alone. The results of these two tests, while not conclusive, indicate that when pigs have the run of fields of alfalfa, corn is as satisfactory a ration as corn and shorts in respect to the rate and cost of gains.

EXPERIMENT 38. RECORD OF PIGS DURING SUMMER OF 1913.

For the summer of 1913 there is an accurate record of 129 pigs fed in six lots from July 23 to October 14. The ration was corn and alfalfa pasture. The average amount of grain fed daily per 100 pounds weight of pig was 2.39 pounds. The average daily gain per pig was 0.66 pound. There were eaten 286 pounds of grain in making 100 pounds of gain. The cost of the grain used in producing 100 pounds of gain was \$2.43. Adding the cost of the alfalfa pasture to this raises the cost of 100 pounds of gain to \$3.05. The records of this summer are given in detail in Table 8.

EXPERIMENT 39. DRY SHELLED CORN COMPARED WITH SOAKED SHELLED CORN FOR GROWING PIGS ON ALFALFA PASTURE.

In the foregoing table, Lots 114 and 117 were composed of two similar lots of pigs. Lots 115 and 118 were similar also. Lots 116 and 119 also were similar. The only difference in the feeding or care of the pigs was that the first lot mentioned in each comparison was fed shelled corn that had been soaked 12 hours while the second lot in each comparison was fed dry shelled corn. In the first two couplets, dry corn gave faster and cheaper gains than soaked corn. In the third couplet, the lot on shelled corn did not do well, and the soaked corn gave faster and cheaper gains than the dry corn. The average of the three lots shows that dry corn and soaked corn gave the same rate of gain with nearly the same amount of dry corn and of soaked corn for 100 pounds of gain. These results indicate that it was not profitable to soak corn for these pigs.

EXPERIMENT 40. RECORD OF GILTS ON GRAIN AND ALFALFA PASTURE DURING FIVE SUMMERS, 1909-1913.

The following table contains the record of the herd of gilts selected each summer for the young dams of the next spring. They were carried thru the summer, after the selection was made, on a medium grain ration and alfalfa pasture. The record of a lot consisting of 25 gilts during five consecutive summers shows that they ate an average of 339 pounds of grain for 100 pounds of gain made at the average rate of 0.92 pound daily per head. There were 2.5 pounds of grain fed daily per 100 pounds weight of the gilts. This ration brought the gilts into the winter quarters weighing 171 pounds each. The record of their performance during the winter is given in Part I of this bulletin.

TABLE 9.—*Growing gilts on grain and alfalfa pasture. Five years' record—1909-1913.*
There were 25 gilts in each lot.

EXPERIMENT 40.

Year.....	1909	1910	1911	1912	1913	Average of 5 years
Date	Aug. 1 Nov. 7	Aug. 3 Nov. 9	Aug. 5 Nov. 8	June 28 Nov. 14	July 23 Oct. 14	
Lot No.....	36	37	105	112	120	
Ration (alfalfa pasture).....	50% Corn 50% Wheat	75% Corn 25% Wheat	100% Corn	100% Corn	100% Corn	Corn Wheat
No. days in experiment	98	98	95	139	83	108
Av. first weight per pig, lbs.	71.6	76.8	97.2	64	76	77.1
Av. last weight per pig, lbs.	156.6	155.6	201.2	188.4	153.4	171.0
Av. gain per pig, lbs.	84.9	78.8	104.0	124.4	77.4	93.9
Av. daily gain per pig, lbs.	.87	.80	1.10	.89	.93	.92
Grain for 100 lbs. gain, lbs.	333	390	355	331	288	339
Cost of grain for 100 lbs. gain	\$3.34	\$3.58	\$2.98	\$2.78	\$2.42	\$3.02
Profit on 100 lbs. gain	2.56	2.31	2.92	3.12	3.48	2.88
Profit per pig	2.17	1.82	3.04	3.88	2.69	2.72
Profit per pig, daily	.022	.018	.032	.028	.032	.026
Grain fed daily per pig, lbs.	2.88	3.13	3.88	2.97	2.69	3.11
Grain fed per 100 lbs. wt. of pig, lbs.	2.53	2.69	2.60	2.35	2.34	2.50
Av. mean wt. per pig, lbs.	114.1	116.2	149.20	126.20	114.70	124
Cost of 100 lbs. gain, pasture included	\$3.69	\$3.95	\$3.25	\$3.11	\$2.74	\$3.35



Fig. 4.—Pigs on alfalfa pasture. Corn and alfalfa pasture form an excellent summer ration.

SUMMARY OF RESULTS OF GROWING PIGS ON ALFALFA PASTURE AND GRAIN.

In the following table we have brought together the records of the various lots fed grain while grazing on alfalfa pasture, and grouped them according to the amount of grain fed per 100 pounds weight of the pigs. The charge for pasture is arbitrarily fixed in accord with the grain ration. The lightest and heaviest rations in this table should not be given too great value as there were few pigs in these groups as compared with the numbers in the three other groups. The heavier grain ration gives a higher cost per 100 pounds of gain than the lighter grain ration but also gives faster gains and by so doing gives more profit per pig in a given time.

Considering the pigs on a 2, 2½, and 3 per cent ration we find the relative daily gains of the three groups are almost the same as the relative amounts of grain fed to the three groups.

The ratio of the cost of grain and pasture for 100 pounds of gain is as 81, 84, and 100 respectively when corn is 47 cents per bushel. As the price of corn is increased, the difference in the cost of gains becomes greater and is more in favor of the lighter rations.

TABLE 10.—*Results of feeding pigs grazing on alfalfa pasture, various amounts of grain.**

SUMMARY OF AVERAGES OF ALL TESTS.

Per cent of feed, approximately	1%	2%	2½%	3%	3½%†	Average
Prices used	Corn, 47c per bushel. Hogs, \$5.90 per 100 lbs.					
No. tests conducted	3	13	18	10	3	.....
No. pigs tested.	64	384	458	349	90	1,345
Per cent of feed fed.	1.0	2.08	2.42	3.0	3.68	2.43
Av. first weight per pig, lbs..	48.6	50.5	60.6	81.0	55.3	59.2
Av. daily gain per pig, lbs..	.38	.56	.73	.90	.92	.69
Charge for alfalfa pasture daily per pig, cents.....	.5	.4	.4	.3	.3	.4
Grain for 100 lbs. gain, lbs..	158	260	312	389	374	298
Cost of grain for 100 lbs. gain	\$1.33	\$2.27	\$2.82	\$3.18	\$3.25	\$2.57
Cost of grain and pasture for 100 lbs. gain.	2.86	3.05	3.18	3.76	3.58	3.29
Daily profit per pig above cost of grain.	.017	.02	.022	.024	.024	.021
Daily profit per pig above cost of grain and pasture..	.012	.016	.018	.021	.021	.017
Prices used	Corn, 50c per bushel. Hogs, \$6.50 per 100 lbs.					
Cost of grain for 100 lbs. gain	\$1.41	\$2.40	\$2.98	\$3.37	\$3.44	\$2.72
Cost of grain and pasture for 100 lbs. gain.	2.94	3.18	3.34	3.95	3.47	3.37
Daily profit per pig above cost of grain.	.019	.023	.025	.028	.028	.025
Daily profit per pig above cost of grain and pasture..	.014	.019	.021	.025	.025	.021
Prices used	Corn, 60c per bushel. Hogs, \$7 per 100 lbs.					
Cost of grain for 100 lbs. gain	\$1.69	\$2.87	\$3.54	\$4.07	\$4.11	\$3.26
Cost of grain and pasture for 100 lbs. gain.	3.22	3.65	3.90	4.65	4.44	3.98
Daily profit per pig above cost of grain.	.02	.023	.025	.026	.026	.024
Daily profit per pig above cost of grain and pasture..	.017	.019	.021	.023	.023	.021
Prices used	Corn, 70c per bushel. Hogs, \$7.50 per 100 lbs.					
Cost of grain for 100 lbs. gain	\$1.98	\$3.34	\$4.10	\$4.47	\$4.78	\$3.73
Cost of grain and pasture for 100 lbs. gain.	3.51	4.12	4.46	5.35	5.11½	4.51½
Daily profit per pig above cost of grain.	.021	.023	.025	.024	.025	.023
Daily profit per pig above cost of grain and pasture..	.016	.019	.021	.021	.022	.019

* There was a small proportion of feeds other than corn fed to certain lots in these comparisons. This is accounted for in the cost of gains.

† There were more of the feeds other than corn fed to this than to the other groups. This accounts for the pigs in this group using less grain for 100 pounds of gain and the gain made by them costing more per 100 pounds than in the other groups.

The ratio of the daily profit per pig when corn is 47 cents per bushel and hogs \$5.90 per 100 pounds is as 76, 85, and 100, and when corn is 70 cents per bushel and hogs \$7.50 per 100 pounds the ratio is as 91, 100, and 100. Higher prices favor the lighter ration of 2 per cent but do not bring as much profit from this ration as from the heavier rations. With corn and hogs at the lowest prices here used, the 3 per cent ration gave the most profit; but with the highest prices used, the $2\frac{1}{2}$ per cent ration gave as much profit as the 3 per cent ration.

It is our opinion that rations lighter than $2\frac{1}{2}$ or 2 per cent are not as profitable as these rations even with the price of corn high, as the light rations do not permit of sufficient growth to keep the hogs in a healthy and thrifty condition. It is seldom that a "runty" lot of pigs gives much profit on any winter ration.

PART IV.**FATTENING HOGS.****EXPERIMENT 41. CORN AND SUPPLEMENTARY FEEDS FOR FATTENING HOGS. WINTER OF 1911-1912.**

Comparisons were made of various ways of feeding corn and protein supplements to corn in fattening hogs in the winter of 1911-1912. Ten lots of 10 pigs each were fed from November 14, 1911, to February 27, 1912—106 days.

The rations fed were as follows:

- Lot 121, Shelled corn.
- Lot 122, Ear corn and alfalfa hay in a rack.
- Lot 123, Shelled corn and alfalfa hay in a rack.
- Lot 124, Ground corn and alfalfa hay in a rack.
- Lot 125, Ground corn 90 parts and alfalfa meal 10 parts.
- Lot 126, Ground corn 90 parts and shorts 10 parts.
- Lot 127, Ground corn 90 parts and oil meal 10 parts.
- Lot 128, Ground corn 95 parts and tankage 5 parts.
- Lot 129, Ground corn 90 parts, oil meal 10 parts, and alfalfa hay in a rack.
- Lot 130, Ground corn 95 parts, tankage 5 parts, and alfalfa hay in a rack.

These rations ranked as follows in rapidity of gains, pounds of feed for 100 pounds of gain, cost of feed for 100 pounds, and profit per hog.

<i>Ranked according to rapidity of gain.</i>	<i>Gain per pig, lbs.</i>
Lot 130, Ground corn 95 parts, tankage 5 parts, and alfalfa hay in a rack.....	1.26
Lot 129, Ground corn 90 parts, oil meal 10 parts, and alfalfa hay in a rack.....	1.25
Lot 128, Ground corn 95 parts and tankage 5 parts.....	1.25
Lot 127, Ground corn 90 parts and oil meal 10 parts.....	1.24
Lot 126, Ground corn 90 parts and shorts 10 parts.....	1.05
Lot 125, Ground corn 90 parts and alfalfa meal 10 parts.....	1.00
Lot 124, Ground corn and alfalfa hay in a rack.....	.90
Lot 122, Ear corn and alfalfa hay in a rack.....	.79
Lot 123, Shelled corn and alfalfa hay in a rack.....	.78
Lot 121, Shelled corn	.78

<i>Ranked according to pounds of feed eaten to produce 100 pounds of gain.</i>		Feed for 100 lbs. gain, lbs.
Lot 127, Ground corn 90 parts and oil meal 10 parts.....		467
Lot 128, Ground corn 95 parts and tankage 5 parts.....		469
Lot 130, Ground corn 95 parts, tankage 5 parts, and al- falfa hay in a rack.....		484
Lot 129, Ground corn 90 parts, oil meal 10 parts, and al- falfa hay in a rack		487
Lot 126, Ground corn 90 parts and shorts 10 parts.....		511
Lot 125, Ground corn 90 parts and alfalfa meal 10 parts..		536
Lot 122, Ear corn and alfalfa hay in a rack.....		586
Lot 124, Ground corn and alfalfa hay in a rack.....		597
Lot 123, Shelled corn and alfalfa hay in a rack.....		603
Lot 121, Shelled corn		610

<i>Ranked according to economy of gain.</i>		Cost of 100 lbs. gain.
Lot 130, Ground corn 95 parts, tankage 5 parts, and al- falfa hay in a rack		\$4.14
Lot 128, Ground corn 95 parts and tankage 5 parts.....		4.21
Lot 127, Ground corn 90 parts and oil meal 10 parts.....		4.23
Lot 129, Ground corn 90 parts, oil meal 10 parts and al- falfa hay in a rack		4.29
Lot 125, Ground corn 90 parts and alfalfa meal 10 parts.		4.45
Lot 126, Ground corn 90 parts and shorts 10 parts.....		4.47
Lot 122, Ear corn and alfalfa hay in a rack.....		4.80
Lot 124, Ground corn and alfalfa hay in a rack.....		4.93
Lot 123, Shelled corn and alfalfa hay in a rack.....		4.93
Lot 121, Shelled corn		5.13

<i>Ranked according to profit per hog.</i>		Profit per hog.
Lot 130, Ground corn 95 parts, tankage 5 parts, and al- falfa hay in a rack.....		\$2.35
Lot 128, Ground corn 95 parts and tankage 5 parts.....		2.25
Lot 127, Ground corn 90 parts and oil meal 10 parts.....		2.20
Lot 129, Ground corn 90 parts, oil meal 10 parts, and al- falfa hay in a rack.....		2.13
Lot 126, Ground corn 90 parts and shorts 10 parts.....		1.59
Lot 125, Ground corn 90 parts and alfalfa meal 10 parts..		1.53
Lot 124, Ground corn and alfalfa hay in a rack.....		.93
Lot 122, Ear corn and alfalfa hay in a rack.....		.92
Lot 123, Shelled corn and alfalfa hay in a rack.....		.80
Lot 121, Shelled corn		.64

In this test the rations containing tankage and the rations containing oil meal gave quite similar results. The ration of 95 parts corn and 5 parts tankage with alfalfa hay in a rack gave the fastest and cheapest gains and the most profit but did not produce 100 pounds of gain with as little feed as either the ration of 90 parts corn and 10 parts oil meal or the ration of 95 parts corn and 5 parts tankage. The last ration mentioned was second in the profit given, and nearly identical with the ration of corn, tankage, and alfalfa hay in all points of comparison. The two rations containing tankage ranked first in most comparisons but only a very little ahead of the ration containing oil meal.

The ration of 90 parts corn and 10 parts oil meal gave slightly cheaper gains and more profit than the same ration with alfalfa hay in a rack. When tankage or oil meal formed part of the ration, the alfalfa hay did not have much influence on the results.

The ration composed of 90 parts corn and 10 parts shorts, and the ration composed of 90 parts corn and 10 parts alfalfa meal gave nearly the same results. In these rations, shorts and alfalfa meal had about the same feeding value.

Ground corn with alfalfa hay in the rack gave slower gains and less profit in this test than a ration of 90 parts corn and 10 parts alfalfa meal.

Ground corn with alfalfa hay in a rack gave faster gains and a little more profit, excluding the cost of grinding, than shelled corn or ear corn with alfalfa in a rack. The margin in favor of the ground corn would not have paid for the grinding.

Ear corn gave slightly faster gains and more profit than shelled corn. It required less corn on the ear than shelled corn or ground corn to produce 100 pounds of gain.

Corn fed alone gave slower gains, required more feed for 100 pounds of gain, produced gains at a greater cost, and gave less profit than any other ration used in the experiment.

During the winter, the weather was unusually severe and rations containing tankage, oil meal or shorts, mill products that stimulated the appetite of the hogs, gave more favorable results in comparison with rations of corn or corn and alfalfa than during the normal winters. The hogs on all rations ate less in proportion to their weight than usual. This resulted in slower gains and consequently more expensive gains and less profit than usual.

TABLE 11.—Comparison of corn with corn and supplementary feeds for fattening hogs. No.
vember 14, 1911, to February 27, 1912—106 days.

There were 10 pigs in each lot.

EXPERIMENT 41.

Lot No.	121	122	123	124	125	126	127	128	129	130
Ration*	S. C. A. H.	E. C. A. H.	S. C. A. H.	Gr. C. A. H.	90% Gr. C. 10% A. M.	90% Gr. C. 10% S.	90% Gr. C. 10% O. M.	95% Gr. C. 5% T.	90% Gr. C. 10% O. M. A. H.	90% Gr. C. 5% T. A. H.
Av. first weight per pig, lbs.	130.30	128.50	126.90	129.70	130.90	130.20	129.00	131.80	133.10	131.10
Av. last weight per pig, lbs.	213.20	212.00	212.10	225.50	236.70	241.20	260.50	264.70	265.50	264.70
Av. gain per pig, lbs.	82.90	83.50	82.20	95.80	105.80	111.00	131.50	132.90	132.40	133.60
Av. daily gain per pig, lbs.	.78	.79	.78	.90	1.00	1.05	1.24	1.25	1.25	1.26
Grain for 100 lbs. gain, lbs.	610	556†	573	570	536	511	467	469	464	442
Alfalfa for 100 lbs. gain, lbs.		30	30	27					23	42
Total feed for 100 lbs. gain, lbs.	610	586	603	597	536	511	467	469	487	484
Cost of feed for 100 lbs. gain	\$5.13	\$4.80	\$4.93	\$4.93	\$4.45	\$4.47	\$4.23	\$4.21	\$4.29	\$4.14
Profit on 100 lbs. gain	.77	1.10	.97	.97	1.45	1.43	1.67	1.69	1.61	1.76
Profit per pig	.64	.92	.80	.83	1.53	1.59	2.20	2.25	2.13	2.35
Profit per pig daily	.006	.008	.007	.009	.014	.015	.021	.021	.02	.022
Grain fed daily per pig, lbs.	4.77	4.39	4.44	5.15	5.35	5.35	5.79	5.88	5.80	5.57
Feed fed daily per pig, lbs.	4.77	4.62	4.67	5.40	5.35	5.35	5.79	5.88	6.08	6.10
Grain fed daily per 100 lbs. weight of pig, lbs.	2.79	2.57	2.60	2.90	2.91	2.89	2.97	2.97	2.91	2.82
Feed fed daily per 100 lbs. weight of pig, lbs.	2.79	2.71	2.73	3.04	2.91	2.89	2.97	2.97	3.05	3.08
Average mean weight per pig, lbs.	171.70	170.20	171.00	177.60	183.80	185.70	194.70	198.20	199.30	197.90

* S. C., shelled corn; E. C., ear corn; Gr. C., ground corn; A. M., alfalfa meal; O. M., oil meal; T., tankage; S., shorts; A. H., alfalfa hay in rack.

† Reduced to shelled corn.

EXPERIMENT 42. CORN AND SUPPLEMENTARY FEEDS FOR
FATTENING HOGS. WINTER OF 1912-1913.

The test of 1911-1912 was duplicated during the winter of 1912-1913 with the results given in Table 12. There was one additional lot in this test. The ration fed this lot was corn 90 parts and cold pressed cottonseed cake 10 parts.

<i>Ranked according to rapidity of gain.</i>		Gain daily per pig, lbs.
Lot 132, Ear corn and alfalfa hay in a rack.....		1.52
Lot 133, Shelled corn and alfalfa hay in a rack.....		1.52
Lot 141, Ground corn 90 parts and cold pressed cotton- seed cake 10 parts.....		1.48
Lot 140, Ground corn 95 parts, tankage 5 parts, and al- falfa hay in a rack.....		1.47
Lot 138, Ground corn 95 parts and tankage 5 parts.....		1.46
Lot 137, Ground corn 90 parts and oil meal 10 parts.....		1.41
Lot 139, Ground corn 90 parts, oil meal 10 parts, and al- falfa hay in a rack.....		1.41
Lot 136, Ground corn 90 parts and shorts 10 parts.....		1.34
Lot 134, Ground corn and alfalfa hay in a rack.....		1.33
Lot 135, Ground corn 90 parts and alfalfa meal 10 parts..		1.24
Lot 131, Ground corn		1.22

<i>Ranked according to feed eaten to produce 100 pounds of gain.</i>		Feed for 100 lbs. gain, lbs.
Lot 132, Ear corn and alfalfa hay in a rack.....		424
Lot 138, Ground corn 95 parts and tankage 5 parts.....		441
Lot 137, Ground corn 90 parts and oil meal 10 parts.....		445
Lot 133, Shelled corn and alfalfa hay in a rack.....		446
Lot 140, Ground corn 95 parts, tankage 5 parts, and al- falfa hay in a rack.....		447
Lot 141, Ground corn 90 parts and cold pressed cotton- seed cake 10 parts.....		454
Lot 139, Ground corn 90 parts, oil meal 10 parts, and al- falfa hay in a rack.....		455
Lot 136, Ground corn 90 parts and shorts 10 parts.....		461
Lot 134, Ground corn and alfalfa hay in a rack.....		482
Lot 135, Ground corn 90 parts and alfalfa meal 10 parts..		497
Lot 131, Ground corn		494

<i>Ranked according to economy of gain.</i>		Cost of 100 lbs. of gain.
Lot 132, Ear corn and alfalfa hay in rack.....		\$3.50
Lot 133, Shelled corn and alfalfa hay in rack.....		3.63
Lot 134, Ground corn and alfalfa hay in rack.....		3.93
Lot 138, Ground corn 95 parts and tankage 5 parts.....		3.96
Lot 140, Ground corn 95 parts, tankage 5 parts, and alfalfa hay in a rack.....		4.00
Lot 141, Ground corn 90 parts and cold pressed cottonseed cake 10 parts.....		4.00
Lot 137, Ground corn 90 parts and oil meal 10 parts.....		4.03
Lot 136, Ground corn 90 parts and shorts 10 parts.....		4.04
Lot 139, Ground corn 90 parts, oil meal 10 parts, and alfalfa hay in a rack.....		4.08
Lot 135, Ground corn 90 parts and alfalfa meal 10 parts..		4.13
Lot 131, Ground corn		4.15

<i>Ranked according to profit per pig.</i>		Profit per pig.
Lot 132, Ear corn and alfalfa hay in a rack.....		\$3.99
Lot 133, Shelled corn and alfalfa hay in a rack.....		3.78
Lot 138, Ground corn 95 parts and tankage 5 parts.....		3.08
Lot 141, Ground corn 90 parts and cold pressed cottonseed cake 10 parts.....		3.07
Lot 140, Ground corn 95 parts, tankage 5 parts, and alfalfa hay in a rack.....		3.04
Lot 137, Ground corn 90 parts and oil meal 10 parts.....		2.88
Lot 134, Ground corn and alfalfa hay in rack.....		2.86
Lot 139, Ground corn 90 parts, oil meal 10 parts, and alfalfa hay in a rack		2.81
Lot 136, Ground corn 90 parts and shorts 10 parts.....		2.72
Lot 135, Ground corn 90 parts and alfalfa meal 10 parts..		2.41
Lot 131, Ground corn		2.34

Nearly all lots rank unusually close together in rate of gain, the amount of feed eaten for 100 pounds of gain, and the cost of 100 pounds of gain. The variation in rate of gain in the 11 lots of 10 pigs each fed on different rations of 0.3 pound per pig daily. In seven lots the variation was only 0.11 pound. In five lots the amount of feed required to make 100 pounds of gain varied only 6 pounds. In the 11 lots this variation amounted to 73 pounds. The cost of the feed eaten to produce 100 pounds of gain varied

22 cents in nine lots. There was more variation than this in the profit per pig, but even this variation was rather small.

In this test, ear corn and alfalfa hay in a rack, and shelled corn and alfalfa hay in a rack tied for first place in rapidity of gains. Ear corn and alfalfa hay in a rack required the least feed for 100 pounds of gain, made 100 pounds of gain at the least cost, and gave the most profit per pig of any of the 11 rations. The ration of shelled corn and alfalfa hay in a rack was next to ear corn and alfalfa hay in the cost of 100 pounds of gain and profit per pig, but was fifth in the amount of feed required to produce 100 pounds of gain. Ground corn and alfalfa hay ranked rather low in the rate of gain and amount of feed eaten for 100 pounds of gain. No charge was made for grinding the corn. The corn was ground for all lots excepting Nos. 132 and 133.

Of the two lots fed 95 parts corn and 5 parts tankage, the lot not given alfalfa ranked the higher in all points of comparison except in the rate of gain, in which comparison the two lots were almost equal. The lots fed these rations ranked near each other in all comparisons excepting in the amount of feed eaten to produce 100 pounds of gain.

The lot fed corn, tankage, and alfalfa hay ate the same amount of corn and tankage to produce 100 pounds of gain as the lot fed corn and tankage, and also ate 5 pounds of alfalfa. In this test the hogs fed tankage gave better results than the hogs fed oil meal, shorts, alfalfa meal, or corn alone, about the same results as the lot fed cold pressed cottonseed cake and not as profitable results as the lots fed ear or shelled corn and alfalfa hay.

The lot fed 90 parts corn and 10 parts cold pressed cottonseed cake was above either lot fed tankage in rate of gain but below both tankage lots in pounds of feed for 100 pounds of gain and cost of 100 pounds of gain and practically tied with the better tankage lot in the profit per pig. In this test, cold pressed cottonseed cake was superior to oil meal in all comparisons excepting in the pounds of feed required to produce 100 pounds of gain.

The pigs fed 90 parts corn and 10 parts oil meal and the pigs fed 90 parts corn and 10 parts oil meal and alfalfa hay in a rack made the same daily gain and ranked together or very close in the other points of comparison. These lots ranked lower in rate of gain than the lots fed tankage or cottonseed cake but about equal to the lot fed ground corn and alfalfa hay in a rack and higher than the lots receiving rations containing corn and shorts or alfalfa meal, or corn alone.

TABLE 12.—Comparison of corn with corn and supplementary feeds for fattening hogs. October 18, 1912, to February 4, 1913—109 days.

EXPERIMENT 42.											
Lot No.	131	132	133	134	135	136	137	138	139	140	141
Ration*	Gr. C.	E. C. ^a A. H.	S. ^c C. A. H.	Gr. C. A. H.	90% Gr. C. 10% A. M.	90% Gr. C. 10% S.	90% Gr. C. 10% O. M.	95% Gr. C. 5% T.	90% Gr. C. 10% O. M. C. A.	95% Gr. C. 5% T. C. A.	10% C. P. C. C. 90% Gr. C.
No. pigs in lot	10	9	9	10	10	10	10	10	10	10	9
Av. first weight per pig, lbs.	102.5	83.5	96.6	98.6	102.8	102.5	105.4	102.5	102.8	105	99.4
Av. last weight per pig, lbs.	236.3	249.8	263.3	243.6	238.7	248.8	259.5	261.3	257.0	265	261.1
Av. gain per pig, lbs.	133.8	166.3	166.7	145.0	135.9	146.3	154.1	158.8	154.2	160	161.7
Av. daily gain per pig, lbs.	1.22	1.52	1.52	1.33	1.24	1.34	1.41	1.46	1.41	1.47	1.48
Grain for 100 lbs. gain, lbs.	494	410	420	456	497	461	445	441	444	442	454
Alfalfa for 100 lbs. gain, lbs.		14	26	26					11	5	
Total feed for 100 lbs. gain, lbs.	494	424	446	482	497	461	445	441	455	447	454
Cost of grain for 100 lbs. gain	\$4.15	\$3.44	\$3.53	\$3.83	\$4.13	\$4.04	\$4.03	\$3.96	\$4.02	\$3.97	\$4.00
Cost of alfalfa for 100 lbs. gain		.06	.10	.10					.06	.03	
Total cost of 100 lbs. gain	4.15	3.50	3.63	3.93	4.13	4.04	4.03	3.96	4.08	4.00	4.00
Profit on 100 lbs. gain	1.75	2.40	2.27	1.97	1.77	1.86	1.87	1.94	1.82	1.90	1.90
Profit per pig daily	2.34	3.99	3.78	2.86	2.41	2.72	2.88	3.08	2.81	3.04	3.07
Grain fed daily per pig, lbs.	.021	.036	.035	.026	.022	.025	.026	.028	.026	.028	.028
Feed fed daily per pig, lbs.	6.06	6.25	6.43	6.06	6.20	6.20	6.28	6.42	6.28	6.49	6.73
Grain fed daily per 100 lbs. wt. of pig, lbs.	6.06	6.46	6.81	6.41	6.20	6.20	6.28	6.42	6.43	6.55	6.73
Feed fed daily per 100 lbs. wt. of pig, lbs.	3.58	3.75	3.57	3.54	3.63	3.53	3.44	3.53	3.48	3.51	3.73
Av. mean weight per pig, lbs.	3.58	3.88	3.79	3.75	3.63	3.53	3.44	3.53	3.57	3.54	3.73
	169.4	166.6	170.9	171.1	170.8	175.7	182.5	181.9	179.9	185.0	180.3

* S. C., shelled corn; E. C., ear corn; Gr. C., ground corn; A. M., alfalfa meal; O. M., oil meal; T., tankage; S., shorts; C. P. C. C., cold pressed cottonseed cake; C. A., cut alfalfa.

† Reduced to shelled corn.

The ration of 90 parts ground corn and 10 parts shorts ranked equal to, or a little higher than, ground corn and alfalfa hay in the rack in rate of gain, and higher in pounds of feed eaten for 100 pounds of gain, but lower in cost of 100 pounds of gain and profit per pig and ranked lower in all comparisons than ear or shelled corn with alfalfa hay in a rack. The ration containing shorts and the ration containing alfalfa meal ranked close to each other in all comparisons with the advantage in favor of the shorts in each comparison. These two rations and the ration of ground corn and alfalfa hay in a rack gave very nearly the same results, with the advantage always in favor of the latter ration.

It is noted that all lots did much better than during the previous winter. We believe this was due to the weather being much more favorable. The change noted in the ranking of the various lots, we attribute largely to the difference in the weather. It has been our observation that corn and alfalfa give better results in comparison with rations containing mill feeds, when the winter is open and the weather mild. It seems apparent that during unfavorable weather it is an advantage to give a ration that will induce the hogs to eat more feed. Usually hogs will eat more corn when fed some tankage, oil meal, or shorts with the corn. This makes the ration more costly, and it may not be profitable if the hogs would eat the same amount of corn and alfalfa without the mill product.

We have observed also that when hogs were out of condition a variety of feeds has stimulated the appetite, caused the hogs to eat more, and thereby give more profitable results than corn and alfalfa, but when the hogs were in good condition and the weather favorable we have not found any ration superior to corn and alfalfa with the usual prices of foodstuffs prevailing. A ration of corn and a small percentage of a mill product having a high protein content usually has given faster gains with less feed for 100 pounds of gain than corn and alfalfa, but usually under normal conditions this ration has not given as much profit as corn and alfalfa.

EXPERIMENT 43. WHEAT AND RYE COMPARED WITH CORN FOR FATTENING HOGS WITH AND WITHOUT ALFALFA HAY.

During the winter of 1913-1914, from October 21, 1913, to January 27, 1914, 98 days, 7 lots of 10 pigs each were fed the following rations with alfalfa hay in racks in addition:

Lot 142, Shelled corn dry.

Lot 143, Whole wheat dry.

- Lot 144, Whole wheat soaked.
- Lot 145, Ground wheat moistened.
- Lot 146, Ground wheat soaked.
- Lot 147, Whole rye soaked.
- Lot 148, Ground rye moistened.

Six other lots were fed the same rations as Lots 142 to 147 inclusive without alfalfa hay. This duplicated all lots excepting Lot 148.

A full feed was given the pigs twice daily. As the relative results from the first group are almost identical with the relative results from the second group, we shall discuss only the combined results of the two groups.

The rations are ranked below according to the rapidity of gain and the pounds of feed required to produce 100 pounds of gain. As Lot 7 was not duplicated it does not appear in these comparisons.

<i>Ranked according to rapidity of gain.</i>	Gain daily per pig, lbs.
Lots 146 and 153, Ground wheat soaked.....	1.41
Lots 145 and 152, Ground wheat moistened.....	1.36
Lots 142 and 149, Shelled corn dry.....	1.11
Lots 144 and 151, Whole wheat soaked.....	1.05
Lots 143 and 150, Whole wheat dry.....	1.02
Lots 147 and 154, Whole rye soaked.....	.88

<i>Ranked according to feed for 100 pounds of gain.</i>	Pounds feed for 100 lbs. gain.
Lots 146 and 153, Ground wheat soaked.....	418
Lots 145 and 152, Ground wheat moistened.....	433
Lots 142 and 149, Shelled corn dry.....	479
Lots 144 and 151, Whole wheat soaked.....	514
Lots 143 and 150, Whole wheat dry.....	519
Lots 147 and 154, Whole rye soaked.....	558

Ground wheat soaked gave faster gains and required less grain for 100 pounds of gain than any other ration. Ground wheat moistened followed closely. If we should admit Lot 148, fed ground rye moistened, into this comparison, it would rank next to ground wheat moistened in rapidity of gain and just lower than corn and higher than whole wheat in the amount of grain required for 100 pounds of gain. But as this lot was not duplicated we do not feel that we should admit it into this comparison.

Whole wheat, either dry or soaked, made slower gains and re-

quired more grain for 100 pounds of gain than dry shelled corn. Whole rye soaked made the slowest gains and required the most grain for 100 pounds of gain of any ration in the test.

Soaking the ground wheat increased the rate of gain slightly and decreased the amount of feed required to produce 100 pounds of gain, 15 pounds. This indicates that soaking the ground wheat increased its feeding efficiency about 4 per cent.

Grinding the wheat increased its feeding efficiency 21 per cent, or one bushel of ground wheat produced as much gain on the hogs as 1.21 bushels of whole wheat. The ground wheat also produced much faster gains than the whole wheat. It is possible that the scattering of whole wheat thinly over the ground and thereby making the hogs eat it slowly, may lessen to a small extent the necessity of grinding.



Fig. 5.—Hogs fattened on wheat. One bushel of ground wheat equals 1.21 bushels of whole wheat.

There was no check lot fed ground rye moistened, but the results from the one lot indicate that grinding the rye increased its efficiency 15 per cent, or 1 bushel of ground rye produced the same gain as 1.15 bushels of whole rye. The ground rye gave a very much faster gain.

One bushel of shelled corn produced the same gain as 1.16 bushels of whole rye and very slightly more gain than one bushel of ground rye. The corn produced much faster gains than the whole rye but not quite as fast gains as the ground rye.

One bushel of ground wheat produced the same gain as 1.2 bushels of shelled corn.

One pound of ground wheat produced the same gain as 1.11 pounds of corn.

One bushel of shelled corn produced slightly more gain than one bushel of whole wheat.

As long as all lots are fed principally on corn, the cost of a bushel of corn affects all lots similarly; but when one lot is fed corn, another lot wheat, and a third lot rye, the relative prices of the grains bear an important part in determining the merit of the various rations. We, therefore, in this experiment give the relative results when corn is 47 cents per bushel and hogs \$5.90 per 100 pounds and also when corn is 65 cents per bushel and hogs \$7.75 per 100 pounds, with wheat 70 cents per bushel and rye 50 cents per bushel in both comparisons.

Ranked according to economy of gain. Corn at

*47 cents per bushel, wheat at 70 cents per
bushel, hogs at \$5.90 per 100 lbs.*

*Cost of 100
lbs. of gain.*

Lots 142 and 149, Shelled corn dry.....	\$3.97
Lots 146 and 153, Ground wheat soaked.....	4.84
Lots 145 and 152, Ground wheat moistened.....	5.00
Lots 147 and 154, Whole rye soaked.....	5.51
Lots 144 and 151, Whole wheat soaked.....	5.92
Lots 143 and 150, Whole wheat dry.....	5.99

*Ranked according to profit per pig. Corn at 47
cents per bushel, hogs at \$5.90 per 100 lbs.*

*Profit per
pig.*

Lots 142 and 149, Shelled corn dry.....	\$2.11
Lots 146 and 153, Ground wheat soaked.....	1.46
Lots 145 and 152, Ground wheat moistened.....	1.21
Lots 147 and 154, Whole rye soaked.....	.34
Lots 144 and 151, Whole wheat soaked.....	Loss
Lots 143 and 150, Whole wheat dry.....	Loss

With these prices prevailing, corn was a more profitable feed than wheat or rye. The corn produced cheaper gains and more profit per pig than wheat or rye. However, when we assign to corn and hogs the prices prevailing while the experiment was in progress, which was 65 cents per bushel for corn and \$7.75 per 100 pounds for hogs, then corn does not hold first place in economy of gain or profit per pig, as is shown in the following comparisons:

*Ranked according to economy of gain. Corn at
65 cents per bushel, hogs at \$7.75 per 100 lbs.*

*Cost of 100
lbs. of gain.*

Lots 146 and 153, Ground wheat soaked.....	\$4.84
Lots 154 and 152, Ground wheat moistened.....	4.99
Lots 142 and 149, Shelled corn dry.....	5.47
Lots 147 and 154, Whole rye soaked.....	5.50
Lots 144 and 151, Whole wheat soaked.....	5.92
Lots 143 and 150, Whole wheat dry.....	5.98

<i>Ranked according to profit per pig. Corn at 65 cents per bushel, hogs at \$7.75 per 100 lbs.</i>		<i>Profit per pig.</i>
Lots 146 and 153, Ground wheat soaked.....		\$4.02
Lots 145 and 152, Ground wheat moistened.....		3.70
Lots 142 and 149, Shelled corn dry.....		2.49
Lots 147 and 154, Whole rye soaked.....		1.97
Lots 144 and 151, Whole wheat soaked.....		1.91
Lots 143 and 150, Whole wheat dry.....		1.80

With these prices prevailing, ground wheat either soaked or moistened gave cheaper gains and more profit per pig than corn, but corn gave cheaper gains and more profit than whole wheat either dry or soaked.

If we should include Lot 7, fed ground rye moistened, in this comparison, it would rank first in cost of 100 pounds of gain because of its relatively low price per bushel, and would rank ahead of corn, and after ground wheat in profit per pig.

There was required considerably more whole soaked rye than whole soaked wheat or dry corn to produce 100 pounds of gain, but as rye was priced at 50 cents per bushel and wheat at 70 cents per bushel, the whole rye gave more profit than the whole wheat. The rate of gain was much less from rye than from wheat.

Soaking the ground wheat decreased the cost of 100 pounds of gain 15 cents, increased the profit per pig 32 cents, and raised the price received per bushel of wheat 4 cents, when hogs were worth \$7.75 per 100 pounds and wheat worth 70 cents per bushel.

Soaking the whole wheat decreased the cost of 100 pounds of gain 6 cents, increased the profit per pig 9 cents, and raised the price received for one bushel of wheat 1 cent, with prices as in the preceding paragraph.

Grinding the wheat and soaking it as compared with feeding whole wheat soaked decreased the cost of 100 pounds of gain \$1.08, increased the profit per pig \$2.11, and raised the price received for one bushel of wheat 21 cents.

Grinding the wheat and moistening it as compared with feeding dry whole wheat decreased the cost of 100 pounds of gain 99 cents, increased the profit per pig \$1.90, and raised the price received for one bushel of wheat 28 cents.

TABLE 13.—*Comparison of corn, wheat, and rye for fattening hogs. Whole grain compared with ground grain. Average of two tests—October 21, 1913, to January 27, 1914—98 days.*

There were 9 pigs in each lot.

EXPERIMENT 43.

Lot No.....	142-149	143-150	144-151	145-152	146-153	147-154
Ration.....	Shelled corn dry	Whole wheat dry	Whole wheat soaked	Ground wheat moistened	Ground wheat soaked	Whole rye soaked
Av. first weight per pig, lbs.	108.8	109 0	107.5	108.8	109.3	109 9
Av. last weight per pig, lbs.	217.9	209.1	210.4	242.7	247.2	196.6
Av. gain per pig, lbs.....	109.1	100.1	102.9	133.9	137.9	86.7
Av. daily gain per pig, lbs.	1.11	1.02	1 05	1.36	1.41	.88
Lbs. grain for 100 lbs. gain, lbs	468	510	504	426	413	546
Lbs. alfalfa for 100 lbs. gain, lbs.	11	9	10	7	5	12
Total feed for 100 lbs. gain, lbs.	479	519	514	433	418	558
Av. mean weight per pig, lbs.	163.4	159.1	158.9	175.8	178.3	153.3
Prices used.....	Corn, 47c per bushel. Hogs, \$5.90 per 100 lbs.					
Cost of feed for 100 lbs. gain	\$3.97	\$5.99	\$5.92	\$5.00	\$4.84	\$5.51
Profit on 100 lbs. of gain..	1.93	.09*	.02*	.90	1.06	.39
Profit per pig.....	2.11	Loss	Loss	1.21	1.46	.34
Profit per pig daily.....	.021	Loss	Loss	.012	.015	.003
Price rec'd per bushel grain	.70	.69	.70	.82½	.84	.535
Prices used.....	Corn, 65c per bushel. Hogs, \$7.75 per 100 lbs.					
Cost of feed for 100 lbs. gain	\$5.47	\$5.98	\$5.92	\$4.99	\$4.84	\$5.50
Profit on 100 lbs. of gain..	2.28	1.77	1.83	2.76	2.91	2.25
Profit per pig.....	2.49	1.80	1.91	3.70	4.02	1.97
Profit per pig daily.....	.025	.019	.019	.037	.041	.02
Price rec'd per bushel grain	.92	.91	.92	1.09	1.13	.71

*Loss on 100 pounds of gain.

TABLE 14.—Comparison of corn, wheat, and rye for fattening hogs. Whole grain compared with ground grain. Duplicate tests in detail. October 21, 1913, to January 27, 1914—98 days.

EXPERIMENT 43.

Lot No.	Ration*	Group I						Group II							
		142	143	144	145	146	147	148	149	150	151	152	153	154	
S. C. dry			W. A. H. dry	W. A. H. soaked	Gr. W. moistened	Gr. W. soaked	W. R. soaked	Gr. R. moistened	A. H. moistened	S. C. dry	W. W. dry	W. W. soaked	Gr. W. moistened	Gr. W. soaked	W. R. soaked
No. pigs in lot.....		10	10	10	10	10	10	10	10	9	9	9	8	9	9
Av. first weight per pig, lbs.....		124	123.5	122	123.2	123.2	123.5	122.2	202.2	93.6	94.6	92.9	94.6	95.3	98.2
Av. last weight per pig, lbs.....		233.5	216.8	219.3	257.8	259.8	205.6	236.5	202.2	201.4	201.4	201.4	227.5	234.6	187.6
Av. gain per pig daily, lbs.....		109.5	93.3	97.3	134.8	136.6	82.1	114.3	108.6	108.6	106.8	108.5	132.9	139.3	91.4
Lbs. grain for 100 lbs. gain, lbs.....		470	542	540	430	425	572	466	465	478	468	488	421	401	519
Lbs. alfalfa for 100 lbs. gain, lbs.....		21	17	19	14	10	23	16	485	478	468	421	401	401	519
Total lbs. feed for 100 lbs. gain.....		491	559	559	444	435	595	482	465	478	468	421	401	401	519
Cost of feed for 100 lbs. gain.....		\$5.53	\$6.39	\$6.38	\$5.07	\$5.00	\$5.81	\$7.72	\$5.40	\$5.57	\$5.46	\$4.90	\$4.88	\$4.88	\$5.19
Profit on 100 lbs. gain.....		2.22	1.36	1.37	2.68	2.75	1.94	3.03	2.35	2.18	2.29	2.85	3.07	2.86	2.56
Profit per pig.....		2.43	1.27	1.33	3.61	3.76	1.59	3.46	2.55	2.33	2.48	3.79	4.28	2.34	2.34
Price received per bushel grain.....		.0247	.013	.0135	.0368	.038	.016	.035	.026	.024	.025	.038	.043	.043	.024
Lbs. grain fed daily per pig.....		.91	.85	.85	1.07	1.09	.67	.82	.93	.97	.99	1.11	1.16	1.16	.75
Lbs. grain fed daily per 100 lbs. weight of pig.....		5.25	5.16	5.36	5.92	5.92	4.79	5.43	5.15	5.21	5.18	5.70	5.70	5.70	4.83
Lbs. grain fed daily per 100 lbs. weight of pig.....		5.48	5.32	5.54	6.12	6.07	4.98	5.63	5.15	5.21	5.18	5.70	5.70	5.70	4.83
Lbs. feed fed daily per 100 lbs. weight of pig.....		2.93	3.03	3.13	3.11	3.09	2.91	3.03	3.48	3.52	3.52	3.54	3.45	3.45	3.40
Av. mean weight per pig, lbs.....		3.06	3.12	3.24	3.21	3.17	3.02	3.14	3.48	3.52	3.52	3.54	3.45	3.45	3.40
Av. mean weight per pig, lbs.....		178.8	170.2	170.7	190.4	191.5	164.6	179.4	147.9	148	147.2	161.1	165.0	165.0	141.9

* S. C., shelled corn; W. W., whole wheat; Gr. W., ground wheat; W. R., whole rye; Gr. R., ground rye; A. H., alfalfa hay.

† Prices: Hogs, per 100 lbs., \$7.75; corn, per bushel, 65 cents; wheat, per bushel, 70 cents; rye, per bushel, 50 cents; alfalfa hay, per ton, \$8.

EXPERIMENT 44. CORN AND ALFALFA COMPARED WITH CORN, SHORTS, AND ALFALFA FOR GROWING AND FATTENING HOGS.

The 64 pigs used in this experiment were fed 3.14 pounds of corn daily per 100 pounds of their weight and ran in an alfalfa pasture from June 28, 1911, when they were weaned, until September 4, 1911, when this experiment began. During this time the average daily gain per pig was 0.82 pound. The amount of corn eaten in producing 100 pounds of increase in weight was 319 pounds. Their record during this time is given in detail under Lot 104, Table 6, summer of 1911.

On September 5, 1911, this lot of 64 pigs was divided into two uniform lots of 32 pigs each. The average weight of those in Lot 155 was 112 pounds and of those in Lot 156, 115 pounds. From this date until November 14, 10 weeks, each lot grazed on alfalfa pasture. Lot 155 was fed 3.34 pounds of ground corn daily per 100 pounds of the weight of the pigs, and Lot 156 was fed 3.30 pounds of a mixture of two-thirds corn and one-third shorts.

The pigs fed corn gained 0.05 pound more per head daily than those fed corn and shorts and ate 19 pounds less grain for 100 pounds gain. Using the prices given in this bulletin, as shown on page 5, the pigs fed corn alone gave 1.6 times as much profit as those fed corn and shorts.

From November 14, 1911, to January 2, 1912, the two lots of hogs were kept in dry lots and were fed the grain rations indicated above with alfalfa hay in racks. The weather was so excessively cold that the gains on both lots were low and quite expensive. During this winter period of seven weeks, Lot 155 was fed 2.48 pounds of grain daily per 100 pounds of the weight of the pigs, and Lot 156 was fed 2.60 pounds. The pigs fed the mixture consisting of 2 parts corn and 1 part shorts gained 0.06 pound more per head daily than those fed corn alone. The pigs getting the former ration required 2 pounds more grain to produce 100 pounds of gain than those getting the ration of corn. The profit per pig was 32 cents for those fed corn alone and 0.4 cent for those fed corn and shorts.

If we combine the summer and the winter periods, we find that the average daily gain was the same on both lots, and that there were required 16 pounds more of the corn and shorts than of the corn alone to produce 100 pounds of gain. The profit on the pigs fed corn alone was almost twice as much as on those fed corn and shorts. This is considering corn worth 47 cents per bushel, shorts \$24 per ton, and hogs \$5.90 per 100 pounds. If the

shorts had cost \$15.17 per ton it would have given the same profit as corn at 47 cents per bushel in this test. On this basis, corn is worth 75 cents per bushel when shorts is worth \$24 per ton.

The data secured in this experiment are given in detail in Table 15.

TABLE 15.—*Comparison of corn and alfalfa with corn, shorts, and alfalfa for growing and fattening hogs. September 5, 1911, to January 2, 1912.*

There were 32 pigs in each lot.

EXPERIMENT 44.

Date	Period I		Period II		Period III	
	Sept. 5, '11 Nov. 14, '11		Nov. 14, '11 Jan. 2, '12		Sept. 5, '11 Jan. 2, '12	
Lot No.....	155	156	155	156	155	156
Ration* (alfalfa pasture, Period I)	Corn	$\frac{2}{3}$ C. $\frac{1}{3}$ S.	Corn	$\frac{2}{3}$ C. $\frac{1}{3}$ S.	Corn	$\frac{2}{3}$ C. $\frac{1}{3}$ S.
No. days in experiment ...	70	70	49	49	119	119
Average first weight per pig, lbs.	112.2	115.3	188.4	188.4	112.2	115.3
Average last weight per pig, lbs.	188.4	188.4	230.6	233.2	230.6	233.2
Average gain per pig, lbs.	76.2	73.1	42.2	44.8	118.4	117.9
Average daily gain per pig, lbs.	1.09	1.04	.86	.92	.99	.99
Grain for 100 lbs. gain	462	481	606	608	513	529
Alfalfa for 100 lbs. gain.			10	13	4	5
Total lbs. feed for 100 lbs. gain	462	481	616	621	517	534
Cost of feed for 100 lbs. gain ...	\$3.88†	\$4.62†	\$5.13	\$5.89	\$4.33	\$5.10
Profit on 100 lbs. gain	2.02	1.28	.77	.01	1.57	.80
Profit per pig	1.54	.94	.32	.004	1.86	.94
Profit per pig, daily	.022	.013	.006	Loss	.015	.008
Grain fed daily per pig, lbs.	5.02	5.02	5.20	5.55	5.1	5.27
Grain fed daily per 100 lbs. weight of pig	3.34	3.30	2.48	2.60	2.97	3.02
Feed fed daily per 100 lbs. weight of pig	3.34	3.30	2.52	2.70	3.00	3.04
Average mean weight of pig, lbs.	150.3	151.8	209.5	210.8	171.4	174.2

* C., corn; S., shorts.

† The cost of alfalfa pasture is not included. At 0.4 cent per head daily the pasture would have cost 36 cents per 100 pounds gain for those in Lot 155, and 38 cents for those in Lot 156. This would make a total cost of feed and pasture for 100 pounds gain in Lot 155, \$4.24, and Lot 156, \$5.

**EXPERIMENT 45. ALFALFA TEA AND ALFALFA TEA GROUNDS
IN A RATION FOR WINTERING SHOATS.**

On February 8, 1912, 20 fall shoats weighing about 50 pounds each were divided into two uniform lots of 10 pigs each. Another lot of 26 pigs weighing 70 pounds each was divided into two uniform lots of 13 pigs each.

The grain ration for all lots was 3 parts corn and 1 part shorts. Chopped alfalfa was kept in racks where each lot had access to it at all times. The feed for Lot 157 was made into a thick slop with warm water. The feed for Lot 158 was wet with tea made by stewing chopped alfalfa for one hour. The alfalfa used for making tea for each feed amounted to about 20 per cent of the grain ration. The amount of liquid put into the feed of Lot 157 and of Lot 158 was the same. These two lots were given all they would eat, but both lots were kept on the same amount of feed. All feed was the same for the two lots except that the feed for Lot 157 was wet with warm water, while the feed for Lot 158 was wet with warm alfalfa tea.

The rations for Lots 159 and 160 were identical excepting that Lot 160 was fed chopped alfalfa which had been stewed for an hour and the tea drawn off, and Lot 159 was fed the same amount of chopped alfalfa unsteamed. In both lots the grain was fed mixed with alfalfa and moistened with warm water. The feed for Lots 159 and 160 was identical excepting that Lot 159 was fed alfalfa with the grain and Lot 160 was fed the same amount of alfalfa after it had been stewed an hour and the tea drawn off. The feed for each lot was wet with warm water.

Lots 157 and 158 should not be compared with Lots 159 and 160. The pigs in the first two lots were not of the same size as those in the latter two lots. Also, the first two lots were fed more in proportion to their weight than the latter two lots.

The following table gives the results of the experiment. The pigs fed the alfalfa tea gained a little faster with less grain for 100 pounds of gain than the pigs that did not receive tea. Also, the pigs fed the alfalfa tea grounds made faster gains with less grain for 100 pounds of gain than those fed alfalfa not stewed. The tea grounds had a more beneficial effect than the tea. The relative gains of Lot 160 and Lot 159 were 100 and 84 respectively; the relative gains of Lot 158 and Lot 157 were 100 and 94 respectively.

The results of this one experiment indicate that there is some value in stewed alfalfa over alfalfa not stewed. The tea from 100 pounds of stewed alfalfa saved 47 pounds of corn. The tea

grounds from 100 pounds of stewed alfalfa saved 67 pounds of corn. The stewing of 100 pounds of alfalfa hay saved 2 bushels of corn and increased the rate of gains. Two bushels of corn at 47 cents per bushel are worth 94 cents; or at 60 cents per bushel, the 2 bushels are worth \$1.20.

TABLE 16.—*The value of alfalfa tea and of alfalfa tea grounds in a winter ration for pigs. February 8, 1912, to March 30, 1912—51 days.*

EXPERIMENT 45.

Lot No.	157	158	159	160
Ration	$\frac{3}{4}$ Corn, $\frac{1}{4}$ Shorts, Cut alfalfa	$\frac{3}{4}$ Corn, $\frac{1}{4}$ Shorts, Cut alfalfa, Alf. tea	$\frac{3}{4}$ Corn, $\frac{1}{4}$ Shorts, Cut alfalfa	$\frac{3}{4}$ Corn, $\frac{1}{4}$ Shorts, Cut alfalfa, Tea gds.
No. pigs in lot	10	10	13	13
Average first weight per pig, lbs.	49.3	52.2	69.3	69.3
Average last weight per pig, lbs.	74.4	79.5	89.0	91.7
Average gain per pig, lbs.	25.1	27.3	19.7	22.4
Average daily gain per pig, lbs.	.50	.53	.38	.45
Relative gain per pig, lbs.	94	100	84	100
Grain for 100 lbs. gain, lbs.	577	530	554	487
Alfalfa for 100 lbs. gain, lbs.	76	71	166	161
Total feed for 100 lbs. gain, lbs.	653	601	720	648
Cost of feed for 100 lbs. gain	\$5.75	\$5.29	\$5.98	\$5.33
Profit on 100 lbs. gain	.15	.61	Loss	.57
Profit per pig	.037	.166	Loss	.127
Profit per pig daily .....	.....	.003	Loss	.002
Grain fed daily per pig, lbs.	2.84	2.84	2.13	2.13
Feed fed daily per pig, lbs.	3.21	3.21	2.35	2.83
Grain fed daily per 100 lbs. wt. of pig	4.59	4.31	2.69	2.64
Feed fed daily per 100 lbs. wt. of pig	5.19	4.88	2.97	3.51
Average mean weight per pig, lbs.	61.8	65.8	79.1	80.5

EXPERIMENT 46. ALFALFA TEA AND ALFALFA TEA GROUNDS IN A RATION FOR WINTERING SHOATS.

A second test was conducted with fall pigs during the winter of 1913-1914. A lot of 28 pigs was divided into two uniform lots of 14 pigs each on January 13, 1914. The average weight of the pigs was 56 pounds. They were kept in the test until April 7, 1914, when their average weight was 103 pounds.

Lot 161 was fed a ration of 90 parts ground corn and 10 parts chopped alfalfa hay; Lot 162 was fed the same amount of ground corn as Lot 161 and all the stewed alfalfa the pigs would eat.

The grain and alfalfa fed to Lot 161 were mixed and moistened with hot water. For Lot 162 the alfalfa was stewed and both the tea and the grounds mixed with the grain. This lot ate about a half more alfalfa than the lot that ate the alfalfa that had not been stewed.

The two lots made nearly the same gain with a slight advantage in favor of the alfalfa tea lot. This lot ate 12 pounds less grain and 35 pounds more alfalfa to produce 100 pounds of gain than the other lot. The cost of 100 pounds of gain on the pigs fed tea was 7 cents higher and the profit per pig was 7 cents less than on the pigs fed the alfalfa without stewing. The results of this test do not indicate that the value of the alfalfa was increased by stewing.

The results of the two tests would not warrant the farmer in going to much, if any, expense to stew alfalfa for hogs.

TABLE 17.—*The value of alfalfa tea and tea grounds in a winter ration for pigs. January 13, 1914, to April 7, 1914—84 days.*

There were 14 pigs in each lot.

EXPERIMENT 46.

Lot No.	161	162
Ration	90% Gr. corn 10% Cut alfalfa	90% Gr. corn 10% Tea grounds
Average first weight per pig, lbs.	56.8	55.9
Average last weight per pig, lbs.	103.5	103.8
Average gain per pig, lbs.	46.7	47.9
Average daily gain per pig, lbs.	.55	.57
Lbs. grain for 100 lbs. gain, lbs.	486	474
Lbs. alfalfa for 100 lbs. gain, lbs.	45	80
Feed for 100 lbs. gain, lbs.	531	554
Cost of feed for 100 lbs. gain.	\$4.31	\$4.38
Profit on 100 lbs. gain.	1.59	1.52
Profit per pig.	.74	.73
Profit per pig daily.	.009	.009
Price received per bushel grain.	.65	.65
Lbs. grain per pig daily.	2.70	2.70
Lbs. feed daily per pig.	3.10	3.16
Lbs. grain daily per 100 lbs. weight of pig. ...	3.37	3.38
Lbs. feed daily per 100 lbs. weight of pig. ...	3.74	3.95
Average mean weight per pig, lbs.	80.1	79.9

PART V.

SUMMARY OF AVERAGES AND ANNUAL FINANCIAL STATEMENTS.**ANNUAL STATEMENTS.**

An accurate record is kept of all grain and alfalfa fed to hogs during the year. The hogs graze on about 40 acres of alfalfa pasture but consume only about one-half of the alfalfa. A rental of \$5 per acre is charged to the hogs. An inventory of the hogs by weight is taken March 1 each year. From the data thus obtained the following annual statements are compiled. These statements give a fair idea of the cost of producing pork on a Nebraska farm, only that the farmer should produce pork cheaper since he is working entirely for profits and is not necessarily feeding hogs the more costly or less profitable rations and does not suffer the loss occasioned by frequent weighings, and other disturbing factors incident to experimental work.

TABLE 18.—Summary of averages. Corn compared with corn and shorts, corn and barley, corn and emmer, corn and wheat, and corn and tankage.

Ration	Corn	Corn, shorts	Corn	Corn, barley	Corn	Corn, emmer	Corn, wheat	Corn	Corn, tankage
No. tests conducted.....	10	10	8	8	3	3	4	7	7
No. pigs tested	168	168	132	132	84	84	64	162	162
Daily gain per pig, lbs	.94	.94	1.19	1.10	1.33	1.14	1.22	1.17	1.45
Feed for 100 lbs. gain, lbs	436	433	478	532	477	529	470	511	459
Cost of 100 lbs. gain.....	\$3.66	\$4.07	\$4.04	\$4.48	\$3.95	\$4.48	\$4.53	\$4.26	\$4.08
Profit per pig.....	1.70	1.34	1.78	1.26	1.95	1.38	1.71	1.83	2.45

Corn vs. Corn and Shorts—Average of 10 tests.
 Corn tied in rapidity of gain.
 Corn required 3 lbs. more feed for 100 lbs. gain.
 Corn cost 41 cents less for 100 lbs. gain.
 Corn gave 36 cents more profit per pig.
 Corn vs. Corn and Barley—Average of 8 tests.
 Corn gave 0.09 lb. the faster daily gain.
 Corn required 55 lbs. less feed for 100 lbs. gain.
 Corn cost 44 cents less for 100 lbs. gain.
 Corn gave 52 cents more profit per pig.
 Corn vs. Corn and Emmer—Average of 3 tests.
 Corn gave 0.19 lb. the faster daily gain.
 Corn required 52 lbs. less feed for 100 lbs. gain.
 Corn cost 53 cents less for 100 lbs. gain.
 Corn gave 57 cents more profit per pig.

Corn vs. Corn and Wheat—Average of 4 tests.
 Corn gave 0.08 lb. the faster gain.
 Corn required 31 lbs. more feed.
 Corn cost 52 cents less for 100 lbs. gain.
 Corn gave 62 cents more profit per pig.
 Corn vs. Corn and Tankage—Average of 7 tests.
 Corn gave 0.28 lb. less daily gain.
 Corn required 52 lbs. more feed for 100 lbs. gain.
 Corn cost 18 cents more per 100 lbs. gain.
 Corn gave 62 cents less profit per pig.
 A ration of corn and alfalfa has been more profitable than any other ration in this comparison, excepting corn and tankage. Several of the tests with tankage were made under conditions which we believe unduly favored the tankage lots.

Pork Production.

STATEMENT 1.—Pounds of pork produced March 1 to March 1 during the following years:

Year	1911-1912		1912-1913		1913-1914	
	Dr.	Cr.	Dr.	Cr.	Dr.	Cr.
March 1. To lbs. pork on hand	21,195	.....	39,202	.....	38,810	.....
To lbs. pork received during year	1,800	.....	.....	.....	200	.....
By lbs. pork sold during year .....	.....	60,786	.....	71,714	.....	56,436
March 1. By lbs. pork on hand .....	.....	39,202	.....	38,810	.....	39,575
To gain in lbs. pork during year	76,993	.....	71,322	.....	57,001	.....
	99,988	99,988	110,524	110,524	96,011	96,011

STATEMENT 2.—Profit on hogs, considering only cost of feed, from March 1 to March 1 of the following years:*

Year	1911-1912		1912-1913		1913-1914	
	Dr.	Cr.	Dr.	Cr.	Dr.	Cr.
To cost of grain during the year	\$3,644.09		\$3,294.32		\$2,661.16	
To cost of alfalfa hay during the year	140.67		94.38		81.60	
To cost of pasture during the year	200.00		200.00		200.00	
By income from hog sales		\$3,574.37		\$5,290.91		\$4,677.39
By value of net gain or loss March 1 (market price)†		1,062.41	29.40			44.07
To labor and profit	652.02		1,672.81		1,778.70	
	\$4,636.78	\$4,636.78	\$5,290.91	\$5,290.91	\$4,721.46	\$4,721.46

* For prices of feed and hogs, see Statement 6.

† On March 1, 1912, there were 18,007 pounds of pork more on hand than on March 1, 1911. This at \$5.90, the market price at North Platte on March 1, 1912, gives a credit of \$1,062.41. On March 1, 1913, there were 392 pounds less of pork on hand than on March 1, 1912. This at \$7.50, the market price at North Platte on March 1, 1913, gives a debit of \$29.40. On March 1, 1914, there were on hand 565 more pounds of pork than on March 1, 1913. This at \$7.80, the market price at North Platte on March 1, 1914, gives a credit of \$44.07.

Pork Production.

STATEMENT 3.—Profit on hogs, considering corn worth 60 cents per bushel and hogs \$5.90 per 100 pounds, from March 1 to March 1 of the following years:

Year	1911-1912		1912-1913		1913-1914	
	Dr.	Cr.	Dr.	Cr.	Dr.	Cr.
March 1. To value of pork on hand at \$5.90	\$1,220.50		\$2,312.92		\$2,301.59	
To cost of feed during year	3,984.76		3,588.70		2,839.51	
March 1. By income from hog sales, at \$5.90		\$5,899.29		\$6,520.92		\$5,664.65
To labor and profit	664.03		619.30		523.55	
	\$5,899.29	\$5,899.29	\$6,520.92	\$6,520.92	\$5,664.65	\$5,664.65
1911-1912 1912-1913 1913-1914						
By interest, depreciation, and upkeep (Statement 5)			\$348.17	\$406.44	\$383.29	
To labor and profit			318.86	212.86	140.26	
Cost of all feed for 100 lbs. of grain			5.175	5.03	4.98	

STATEMENT 4.—*Profit on hogs, considering corn worth 57 cents per bushel and hogs \$5.90 per 100 pounds, from March 1 to March 1 of the following years:*

Year.....	1911-1912		1912-1913		1913-1914	
	Dr.	Cr.	Dr.	Cr.	Dr.	Cr.
March 1. To value of pork on hand, at \$5.90.....	\$1,250.50		\$2,312.92		\$2,301.59	
To cost of feed during the year.....	3,291.34		2,961.71		2,571.06	
March 1. By income from hog sales, at \$5.90.....	1,357.45	\$5,899.29	1,246.29	\$6,520.92	792.00	\$5,664.65
To labor and profit.....	\$5,899.29	\$5,899.29	\$6,520.92	\$6,520.92	\$5,664.65	\$5,664.65

	1911-1912	1912-1913	1913-1914
By interest, depreciation, and upkeep (Statement 5)	\$327.77	\$387.63	\$383.29
To labor and profit.....	1,029.63	858.66	408.71
Cost of all feed for 100 lbs. of gain.....	4.275	4.15	4.52

STATEMENT 5.—*Interest, depreciation, and upkeep per year for the following years:*

Year.....	1911-1912	1912-1913	1913-1914
March 1. 6 per cent on value of hogs on hand at \$5.90.....	\$75.03	\$138.78	\$138.10
6 per cent on cost of grain for 6 months (corn 60c)	113.14	107.66	85.19
6 per cent on inventory in buildings (\$1,000)	60.00	60.00	60.00
10 per cent depreciation and upkeep on buildings	100.00	100.00	100.00
	\$348.17	\$406.44	\$383.29

STATEMENT 6.—Pounds of grain eaten per 100 pounds of gain and cost of 100 pounds of gain with corn at various prices; also average selling price of hogs from March 1 to March 1 of the following years:

Year	1911-1912	1912-1913	1913-1914
Pounds of grain for 100 lbs. of gain.....	436	414	405
Cost of feed (alfalfa and grain) for 100 lbs. of gain—Corn per bushel 70 cts., 60 cts., 50 cts., 47 cts.,	\$5.86 5.17 4.48 4.28	\$5.63 4.96 4.29 4.15	\$5.34 4.98 4.62 4.51
Average selling price of hogs per 100 lbs.....	7.52	7.38	8.29

STATEMENT 7.—Total amount of feed eaten by the hogs from March 1 to March 1 of the following years; also average cost of feed during these years:

Year—Price per bushel or ton.....	1911-1912	1912-1913	1913-1914	Price
Bushels of corn	5,334	4,823	2,065	\$0.65
Bushels of wheat	127	10 4	1,452	.70
Bushels of rye	42.5	.50	400	.50
Bushels of oats	30	.40	149	.35
Bushels of barley .....	.....	.....	6	.40
Bushels of cane	8.75	.75	.....	.....
Tons of shorts	5.8	5.97	.16	26.00
Tons of oil meal	2.73	1.02	.51	30.00
Tons of alfalfa meal	3.60	3.04	.61	15.00
Tons of cottonseed cake .....	.....	.33	.....	30.00
Pounds of bone meal	96	.....	.....	.....
Pounds of tankage	1,255	3,840	860	45.00
Tons of cut alfalfa	7.65	7.75	6	10.00
Tons of alfalfa hay	3.24	2.11	2.7	8.00

The bulk of the feed was corn and alfalfa, excepting in 1913-1914 when wheat replaced most of the corn. Only a very small amount of mill feeds was used. The 40 acres of alfalfa pasture produced 2.25 tons of hay per acre. This is 54 per cent as much as the fields not pastured. (2-12-15-7M.)

Files

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THE UNIVERSITY OF NEBRASKA.

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OF
NEBRASKA.

VOLUME XXVII, ARTICLE IV.

PORK PRODUCTION.

REPORT OF EXPERIMENTAL SUBSTATION, NORTH PLATTE, NEBRASKA.

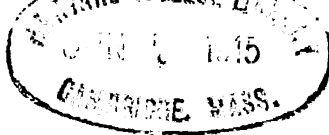
W. P. SNYDER, Superintendent.
E. A. BURNETT, Director.

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LINCOLN, NEBRASKA
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PORK PRODUCTION.*

BY W. P. SNYDER.†

INTRODUCTION.

This bulletin reports the work done with hogs during the years 1912, 1913, and 1914. That the results in former bulletins may be compared readily with the results here reported, the same prices for feed and hogs have been used. During recent years the price of both corn and hogs has risen. The average price paid for corn by the Substation during the three years under consideration was 51.3 cents per bushel and the average net price received for hogs was \$7.04 per 100 pounds. These prices give much more profit on the hogs than the prices used in this bulletin, which are as follows:

Hogs, per 100 pounds	\$5.90
Corn, per bushel	.47
Wheat, per bushel	.70
Barley, per bushel	.40
Rye, per bushel	.56
Oil meal, per ton	30.00
Tankage, per ton	40.00
Shorts, per ton	24.00
Alfalfa meal, per ton	15.00
Chopped alfalfa, per ton	10.00
Alfalfa hay, per ton	8.00

Where chopped alfalfa or alfalfa meal was a part of any ration in the experiment, all the grain was ground. The alfalfa meal was mixed with the grain; the chopped alfalfa was put into the trough and the grain poured over it. The feed was weighed separately for each lot at each feeding time. The hogs had access to water at all times unless the weather was such that the water froze quickly. During the summer, a constant supply of fresh water

* A more extended bulletin of the same number may be had upon application for the LIMITED EDITION.

† The author is indebted to Mr. B. M. Stackhouse for his efficient help in keeping the records and in compiling the tables.

was furnished in the fields by means of a gravity water system that kept fresh water in cement troughs at all times. In all experiments the hogs were weighed every second week.

WINTERING OLD BROOD SOWS.

Two rations for wintering old brood sows were tried during four consecutive winters. The purpose was to test the advisability of feeding a ration of chopped alfalfa hay mixed with an equal weight of ground grain, and of feeding the alfalfa hay in a rack and feeding shelled corn in a trough. Each of these two rations was fed to 10 sows from early in November until the first or middle of March, or for 121 days on the average. The feed consumed daily amounted to 1.13 pounds of grain and 0.19 pound of alfalfa hay per 100 pounds weight of the sows in the lots fed hay in a rack. The corresponding figures for the hogs fed chopped alfalfa hay and chopped grain mixed are 1.04 pounds of grain and 1.05 of alfalfa hay. The average daily gain of the sows getting alfalfa from a rack was 0.76 pound per head. Of those eating equal amounts by weight of corn and chopped alfalfa hay, the average daily gain was 0.79 pound. The sows eating alfalfa from the rack were fed 1 bushel more grain but ate 400 pounds less hay during the winter than the other sows. The average cost of feed for wintering a sow fed grain and alfalfa hay in a rack was \$5.29. The average cost of feed for wintering a sow on half grain and half chopped alfalfa hay mixed was \$6.92. The average gain in weight of the sows fed the former ration was 93 pounds, and of the latter ration, 96 pounds. The gain produced by the two rations was nearly the same, but the cost of feed for wintering a sow on the ration of corn and alfalfa mixed was \$1.63 more than on the other ration. With the prices of feed and hogs as stated, the average gain in weight of the sows fed alfalfa hay in a rack more than paid for the feed eaten, while the average gain on the sows fed half grain and half alfalfa lacked \$1.25 of paying the cost of the feed eaten.

The average of the four tests shows that it required 9.9 bushels of corn and 86 pounds of alfalfa hay, or 8.84 bushels of corn and 495 pounds of chopped alfalfa hay, to keep a sow weighing 387 pounds thru the winter of four months and increase her weight about 95 pounds. It is probable that half alfalfa is too great a proportion for feeding to hogs even for keeping them thru the winter when little or no gain in weight is desired. When hogs eat alfalfa from a rack, it is very important that the hay be of the best quality.

In these four tests, feeding a very light grain ration and letting

the sows eat alfalfa at will from a rack proved a better practice than mixing the grain and chopped alfalfa in equal proportions and thereby compelling the sows to eat a pound of alfalfa with each pound of grain.

WINTERING YOUNG BROOD SOWS.

During five consecutive winters gilts were wintered on a ration of 1 pound of chopped alfalfa hay mixed with from 2 to 3 pounds of grain. There were from 20 to 25 gilts in the lot each winter. The gilts were fed all they cared to eat of the mixture. When there was some indication that they were becoming too fleshy the percentage of alfalfa to grain was increased. They were always in rather heavy flesh at the time of farrowing and produced rather large litters of healthy pigs.



Fig. 1.—Gilts near farrowing. Wintered on grain and alfalfa.

The gilts were farrowed during the latter part of March or in April and were fed a medium grain ration during the summer while grazing on alfalfa pasture. At no time were they given a full grain ration.

When the winter feeding period began, about November 10, the average weight of the gilts was 178 pounds. During the winter the average daily gain per gilt was 0.91 pound. The winter period was closed shortly before the first gilt farrowed. This ranged from March 14 to April 1. At that time the average weight was 301 pounds per gilt.

There were required on the average 477 pounds of grain and 181 pounds of alfalfa to produce 100 pounds of gain. At the prices assumed in this bulletin the average cost of grain and alfalfa eaten in producing 100 pounds of gain was \$5.30.

The average amount of grain fed daily per 100 pounds weight

of hog was 1.63. This is too light a grain ration to produce fast or cheap gains. The alfalfa increased this to 2.48 pounds, which is still too light a ration for the most profitable results when fattening hogs. However, this ration gave the hogs as much bulk as they would eat, which may be an advantage, and brought them forward to the time of farrowing sufficiently fast and in a high enough condition of flesh.

That no trouble occurred at the time of farrowing and that fairly large, healthy litters were farrowed is an indication that the ration has some merit. A smaller percentage of alfalfa probably would have given cheaper as well as faster gains, but would have made the gilts too fleshy unless the amount fed had been kept considerably below a full feed.

The feed eaten by the average gilt during the four and one-half months was equal in value to 13.5 bushels of corn. It cost a few cents more to winter a gilt than an old sow, as these hogs were wintered, but the period for the gilts was two weeks longer and also the gain per head was greater than with the old sows. The net cost of wintering the gilt was less than that of wintering the old sow, since the gilt made more gain than the old sow for the feed eaten. Slow gains are usually more expensive than fast gains. The value of the sow ready to farrow in the spring above the value of the unbred sow of the same weight in the fall should be considered when studying the cost of gains made on sows while being wintered.

FOOD COST OF THE 50-POUND PIG.

We have endeavored to determine the cost of the feed used in producing the average 50-pound pig raised on the Substation farm during the past four years. The sows were wintered as indicated on the previous pages. The record covers only the period from the time the sow was put into winter quarters, about November 1, until her spring litter had been weaned and the pigs had reached an average weight of 50 pounds.

All feed eaten by the sow during the time indicated above and all feed eaten by the pigs until their average weight was 50 pounds each is charged to the sow. She is credited with the gain made in her weight between the time she went into winter quarters and the time her pigs reached the 50-pound weight. She is also credited with the total weight of her pigs when their average weight was 50 pounds.

There is no account taken of any cost except that of feed. Labor, interest on investment, and risk—excepting the risk on young pigs—are not taken into account. These figures are intended to give the cost of the feed used in producing a 50-pound pig.

PIGS FROM OLD SOWS.

This is the record of an average of 18 sows per winter for four winters. The sows were carried thru the winter on corn and alfalfa, as has been stated. The average gain on the sows from fall until they farrowed in the spring was 125 pounds. They lost about half of this gain while farrowing and suckling the litters but weighed an average of 62 pounds more when the pigs were weaned than when they went into winter quarters the previous fall. These 62 pounds are credited to the sows at \$5.90 per 100 pounds.

The average cost of the feed per sow from fall until she farrowed was \$6.98, or the equivalent of 11.52 bushels of corn at 47 cents per bushel. The average cost of the feed eaten by the sow



Fig. 2.—The 50-pound pig. Cost of feed about \$2.

from the time she farrowed until her pigs were weaned, and of the feed eaten by the pigs until their average weight was 50 pounds each, was \$10.43. The average cost of all the feed used by the sow and her litter was \$17.41. The value of the 62 pounds gain on the sow reduced this to a net cost of \$13.76. This is the net cost of the feed used in producing the litter to the average weight of 50 pounds per pig.

An average of 11.1 pigs was farrowed per sow. The average weight of each pig at birth was 2.4 pounds. When the average weight of the pigs was 50 pounds each, then the average number of pigs per litter was only 6.55. From the date of being farrowed until the 50-pound weight was reached, the pigs gained at the rate of 0.53 pound each daily and reached the 50-pound weight when 89 days old.

The average cost of the feed used in producing the 50-pound pig as here calculated is \$2.11.

PIGS FROM YOUNG SOWS.

A record of an average of 24 young sows for five years follows. The gilts gained an average of 149 pounds each during the winter at a cost of \$7.28 for feed. This gave an average net profit of \$1.59 per head above cost of feed, considering corn worth 47 cents per bushel. They ate during the winter the equivalent in value of 12.72 bushels of corn per head. The cost of the feed eaten by the average sow, from the time she farrowed until her pigs were weaned, and by the pigs, until their average weight was 50 pounds each, was \$8.46; or the cost of all feed for sow and litter from fall until the average pig weighed 50 pounds was \$16.41. The average increase in weight of the sow during the experiment was 101.4 pounds. This at \$5.90 per 100 pounds reduced the cost of feed to a net cost of \$10.43 per sow and litter.

The average sow farrowed 8.2 pigs weighing 2.31 pounds each at birth. When the average weight of 50 pounds was reached, the number had decreased to 6.2. From the date of being farrowed until the 50-pound weight was reached, the average pig gained at the rate of one-half pound daily and reached the 50-pound weight when 99 days old.

According to this record and this method of calculation, the cost of feed used in producing the average 50-pound pig from the young sow was \$1.68.

COST OF FALL AND SPRING PIGS COMPARED.

The costs of the feed used in growing the fall pig and spring pig are compared by using a record covering a period of four years and including 579 spring pigs from old sows, 543 spring pigs from young sows, and 153 fall pigs from old sows. For this comparison the time considered is only for the period beginning just before the sow farrowed and ending when the average weight of the pigs was 50 pounds each. The fall pigs were farrowed between the middle of September and the middle of October.

In comparing the records of the old and young sows for the short period in the spring, we find that the young sows ate less grain than the old sows, raised nearly as many pigs, and grew them to the 50-pound weight nearly as quickly as the old sows. In the record of the short period, the average cost of feed eaten to produce the 50-pound spring pig of the old sow was \$2.05 and of the young sow \$1.81. The cost of feed to produce the 50-pound pig of the old sow in the fall, considering only the short period, was \$2.03. There was slightly more feed used per pig in the fall than in the spring but less loss of weight on the sow in the fall. There was about one-half pig more per litter raised in the spring than in the fall.

These results indicate pretty strongly that under western Nebraska conditions the fall pig may be grown from the time it is farrowed until it weighs 50 pounds as cheaply as the spring pig during the same period of its life.

COST OF PIGS FROM OLD SOWS AND YOUNG SOWS COMPARED.

The record of a rather large number of sows for four years indicates that young sows produce pigs cheaper than old sows chiefly because they are smaller and therefore require less feed for maintenance and use a greater proportion of their feed in increasing their own weight and the weight of their pigs. The young sows raised almost as many pigs and grew them almost as rapidly as the old sows. While carrying the litters, the young sows made more gain than the old sows and made this on less feed. However, these young sows weighed over 300 pounds each at farrowing time. Considering the period beginning when the sows went into winter quarters and ending when the average weight of the pigs was 50 pounds, the cost of feed used in producing the 50-pound pig from the old sows was \$2.11 and from the young sows \$1.68. If, however, we consider only the period beginning just before the pigs are farrowed and ending when the 50-pound weight has been reached, then the cost of the old sows' pigs is \$2.01 each and of the young sows' pigs \$1.81 each.

COST OF GROWING PIGS ON ALFALFA PASTURE AND GRAIN.

Accurate records have been kept on the performance of 1,345 pigs fed in 50 lots during the summer on alfalfa pasture and various grain rations. These results indicate that the rate of gain bears a close relation to the amount of grain fed and that the cost of gain increases with the rate of the gain. The alfalfa pasture is cheap and the grain is expensive. Gains are cheap or dear, depending on whether they come largely from the pasture or the grain. The greatest profit per pig for a given time is usually from the pig fed a rather heavy grain ration. This is true even if corn is valued at 70 cents per bushel when hogs are valued at \$7.50 per 100 pounds. However, the profit secured during the summer or grazing period may not be the correct basis for determining the most profitable ration.

On the average, pigs that were fed 2 pounds of grain daily for 100 pounds of their weight gained at the rate of 0.56 pound daily and ate 260 pounds of grain for 100 pounds of gain. Those fed 2.5 pounds of grain daily for 100 pounds of their weight gained at the rate of 0.73 pound per head daily and ate 312 pounds

of grain for each 100 pounds increase in their weight. The pigs fed 3 pounds of grain daily for 100 pounds of their weight gained at the rate of 0.90 pound per head daily and ate 389 pounds of grain for each 100 pounds of gain. A few tests indicated that a ration of less than 2 pounds daily per 100 pounds of weight is likely to produce some stunted pigs.

SHORTS FOR PIGS ON ALFALFA PASTURE.

During the summer of 1912 two lots of 25 pigs each, while grazing on alfalfa pasture, were fed shelled corn, and a similar lot of 25 pigs kept under like conditions was fed a ration of three-fourths corn and one-fourth shorts. One lot of pigs fed corn gave exactly the same gain with the same amount of feed for 100 pounds of gain as the lot fed corn and shorts. The other lot fed corn gained slightly faster and used less grain for 100 pounds of gain than the lot fed corn and shorts. There were two other lots of 25 pigs each kept under the same conditions. The pigs in one lot were fed corn and those in the other lot were fed half corn and half shorts. Of these two lots, the latter gained somewhat the faster and required less feed to produce 100 pounds of gain. But with shorts valued at \$24 per ton and corn at 47 cents per bushel, the pigs fed only corn made the cheaper gains. The profit was nearly the same from either ration. The results from the two tests, while not conclusive, would not warrant one in feeding shorts with corn to pigs grazing on alfalfa pasture when the price per ton of shorts is higher than that of corn.

SOAKED OR DRY CORN FOR PIGS ON ALFALFA PASTURE.

During the summer of 1913, three lots of from 20 to 25 pigs each running on alfalfa pasture were fed dry shelled corn, while three similar lots were fed shelled corn soaked from one feed until the next. Two of the lots fed dry corn made faster and cheaper gains than the corresponding lots fed soaked corn. Of the other two lots, the one fed soaked corn made the faster and the cheaper gain, but its companion lot fed dry corn did not give normal results. The record of other similar pigs indicated that the pigs in this lot did not do as well as would reasonably have been expected. The results of the six lots indicate that there was no advantage in soaking the corn for these pigs.

FIVE SUMMERS' RECORD ON GILTS.

During each of five summers a herd of 25 gilts selected for producing pigs was fed a ration of 2.5 pounds of grain daily per 100

pounds of their weight, while grazing on alfalfa pasture. The record shows that they ate 339 pounds of grain for 100 pounds of gain made at the rate of 0.92 pound daily per head. This ration brought the gilts into the winter quarters weighing 171 pounds each.

CORN AND SUPPLEMENTARY FEEDS FOR FATTENING HOGS.

WINTER OF 1911-1912.

Comparisons were made of various ways of feeding corn and protein supplements to corn in fattening hogs in the winter of 1911-1912. Ten lots of 10 pigs each were fed from November 14, 1911, to February 27, 1912—106 days.

The rations fed were as follows:

- Lot 121, Shelled corn.
- Lot 122, Ear corn and alfalfa hay in a rack.
- Lot 123, Shelled corn and alfalfa hay in a rack.
- Lot 124, Ground corn and alfalfa hay in a rack.
- Lot 125, Ground corn 90 parts and alfalfa meal 10 parts.
- Lot 126, Ground corn 90 parts and shorts 10 parts.
- Lot 127, Ground corn 90 parts and oil meal 10 parts.
- Lot 128, Ground corn 95 parts and tankage 5 parts.
- Lot 129, Ground corn 90 parts, oil meal 10 parts, and alfalfa hay in a rack.
- Lot 130, Ground corn 95 parts, tankage 5 parts, and alfalfa hay in a rack.

These rations ranked as follows in rapidity of gains, pounds of feed for 100 pounds of gain, cost of feed for 100 pounds, and profit per hog:

<i>Ranked according to rapidity of gain.</i>		Gain per pig, lbs.
Lot 130, Ground corn 95 parts, tankage 5 parts, and alfalfa hay in a rack		1.26
Lot 129, Ground corn 90 parts, oil meal 10 parts, and alfalfa hay in a rack.....		1.25
Lot 128, Ground corn 95 parts and tankage 5 parts.....		1.25
Lot 127, Ground corn 90 parts and oil meal 10 parts.....		1.24
Lot 126, Ground corn 90 parts and shorts 10 parts.....		1.05
Lot 125, Ground corn 90 parts and alfalfa meal 10 parts..		1.00
Lot 124, Ground corn and alfalfa hay in a rack.....		.90
Lot 122, Ear corn and alfalfa hay in a rack.....		.79
Lot 123, Shelled corn and alfalfa hay in a rack.....		.78
Lot 121, Shelled corn		.78

Ranked according to pounds of feed eaten to produce 100 pounds of gain.

	Feed for 100 lbs. gain, lbs.
Lot 127, Ground corn 90 parts and oil meal 10 parts.....	467
Lot 128, Ground corn 95 parts and tankage 5 parts.....	469
Lot 130, Ground corn 95 parts, tankage 5 parts, and alfalfa hay in a rack	484
Lot 129, Ground corn 90 parts, oil meal 10 parts, and alfalfa hay in a rack	487
Lot 126, Ground corn 90 parts and shorts 10 parts.....	511
Lot 125, Ground corn 90 parts and alfalfa meal 10 parts..	536
Lot 122, Ear corn and alfalfa hay in a rack.....	586
Lot 124, Ground corn and alfalfa hay in a rack.....	597
Lot 123, Shelled corn and alfalfa hay in a rack.....	603
Lot 121, Shelled corn	610

Ranked according to economy of gain.

	Cost of 100 lbs. gain.
Lot 130, Ground corn 95 parts, tankage 5 parts, and alfalfa hay in a rack	\$4.14
Lot 128, Ground corn 95 parts and tankage 5 parts.....	4.21
Lot 127, Ground corn 90 parts and oil meal 10 parts....	4.23
Lot 129, Ground corn 90 parts, oil meal 10 parts, and alfalfa hay in a rack	4.29
Lot 125, Ground corn 90 parts and alfalfa meal 10 parts,	4.45
Lot 126, Ground corn 90 parts and shorts 10 parts.....	4.47
Lot 122, Ear corn and alfalfa hay in a rack.....	4.80
Lot 124, Ground corn and alfalfa hay in a rack.....	4.93
Lot 123, Shelled corn and alfalfa hay in a rack.....	4.93
Lot 121, Shelled corn	5.13

Ranked according to profit per hog.

	Profit per hog.
Lot 130, Ground corn 95 parts, tankage 5 parts, and alfalfa hay in a rack	\$2.35
Lot 128, Ground corn 95 parts and tankage 5 parts.....	2.25
Lot 127, Ground corn 90 parts and oil meal 10 parts....	2.20
Lot 129, Ground corn 90 parts, oil meal 10 parts, and alfalfa hay in a rack	2.13
Lot 126, Ground corn 90 parts and shorts 10 parts.....	1.59
Lot 125, Ground corn 90 parts and alfalfa meal 10 parts..	1.53
Lot 124, Ground corn and alfalfa hay in a rack.....	.93
Lot 122, Ear corn and alfalfa hay in a rack.....	.92
Lot 123, Shelled corn and alfalfa hay in a rack.....	.80
Lot 121, Shelled corn	.64

WINTER OF 1912-1913.

The test of 1911-1912 was duplicated during the winter of 1912-1913. There was one additional lot in this test. The ration fed this lot was corn 90 parts and cold pressed cottonseed cake 10 parts.

<i>Ranked according to rapidity of gain.</i>	Gain daily per pig, lbs.
Lot 132, Ear corn and alfalfa hay in a rack.....	1.52
Lot 133, Shelled corn and alfalfa hay in a rack.....	1.52
Lot 141, Ground corn 90 parts and cold pressed cottonseed cake 10 parts	1.48
Lot 140, Ground corn 95 parts, tankage 5 parts, and alfalfa hay in a rack.....	1.47
Lot 138, Ground corn 95 parts and tankage 5 parts.....	1.46
Lot 137, Ground corn 90 parts and oil meal 10 parts.....	1.41
Lot 139, Ground corn 90 parts, oil meal 10 parts, and al- falfa hay in a rack.....	1.41
Lot 136, Ground corn 90 parts and shorts 10 parts.....	1.34
Lot 134, Ground corn and alfalfa hay in a rack.....	1.33
Lot 135, Ground corn 90 parts and alfalfa meal 10 parts..	1.24
Lot 131, Ground corn	1.22

<i>Ranked according to feed eaten to produce 100 pounds of gain.</i>	Feed for 100 lbs. gain, lbs.
Lot 132, Ear corn and alfalfa hay in a rack.....	424
Lot 138, Ground corn 95 parts and tankage 5 parts.....	441
Lot 137, Ground corn 90 parts and oil meal 10 parts.....	445
Lot 133, Shelled corn and alfalfa hay in a rack.....	446
Lot 140, Ground corn 95 parts, tankage 5 parts, and al- falfa hay in a rack	447
Lot 141, Ground corn 90 parts and cold pressed cotton- seed cake 10 parts	454
Lot 139, Ground corn 90 parts, oil meal 10 parts, and al- falfa hay in a rack	455
Lot 136, Ground corn 90 parts and shorts 10 parts.....	461
Lot 134, Ground corn and alfalfa hay in a rack.....	482
Lot 135, Ground corn 90 parts and alfalfa meal 10 parts..	497
Lot 131, Ground corn	494

<i>Ranked according to economy of gain.</i>		Cost of 100 lbs. of gain.
Lot 132, Ear corn and alfalfa hay in a rack.....		\$3.50
Lot 133, Shelled corn and alfalfa hay in a rack.....		3.63
Lot 134, Ground corn and alfalfa hay in a rack.....		3.93
Lot 138, Ground corn 95 parts and tankage 5 parts.....		3.96
Lot 140, Ground corn 95 parts, tankage 5 parts, and alfalfa hay in a rack.....		4.00
Lot 141, Ground corn 90 parts and cold pressed cotton-seed cake 10 parts		4.00
Lot 137, Ground corn 90 parts and oil meal 10 parts.....		4.03
Lot 136, Ground corn 90 parts and shorts 10 parts.....		4.04
Lot 139, Ground corn 90 parts, oil meal 10 parts, and alfalfa hay in a rack.....		4.08
Lot 135, Ground corn 90 parts and alfalfa meal 10 parts..		4.13
Lot 131, Ground corn		4.15

<i>Ranked according to profit per pig.</i>		Profit per pig.
Lot 132, Ear corn and alfalfa hay in a rack.....		\$3.99
Lot 133, Shelled corn and alfalfa hay in a rack.....		3.78
Lot 138, Ground corn 95 parts and tankage 5 parts.....		3.08
Lot 141, Ground corn 90 parts and cold pressed cotton-seed cake 10 parts		3.07
Lot 140, Ground corn 95 parts, tankage 5 parts, and alfalfa hay in a rack.....		3.04
Lot 137, Ground corn 90 parts and oil meal 10 parts.....		2.88
Lot 134, Ground corn and alfalfa hay in a rack.....		2.86
Lot 139, Ground corn 90 parts, oil meal 10 parts, and alfalfa hay in a rack.....		2.81
Lot 136, Ground corn 90 parts and shorts 10 parts.....		2.72
Lot 135, Ground corn 90 parts and alfalfa meal 10 parts..		2.41
Lot 131, Ground corn		2.34

It is noted that all lots did much better than during the previous winter. We believe this was due to the weather being much more favorable. The change noted in the ranking of the various lots, we attribute largely to the difference in the weather. It has been our observation that corn and alfalfa give better results in comparison with rations containing mill feeds, when the winter is open and the weather mild. It seems apparent that during unfavorable weather it is an advantage to give a ration that will induce the hogs to eat more feed. Usually hogs will eat more corn when fed some tankage, oil meal, or shorts with the corn.

This makes the ration more costly, and it may not be profitable if the hogs would eat the same amount of corn and alfalfa without the mill product.

We have observed also that when hogs were out of condition a variety of feeds has stimulated the appetite, caused the hogs to eat more, and thereby give more profitable results than corn and alfalfa, but when the hogs were in good condition and the weather favorable we have not found any ration superior to corn and alfalfa with the usual prices of foodstuffs prevailing. A ration of corn and a small percentage of a mill product having a high protein content usually has given faster gains with less feed for 100 pounds of gain than corn and alfalfa, but usually under normal conditions this ration has not given as much profit as corn and alfalfa.

**WHEAT AND RYE COMPARED WITH CORN FOR FATTENING HOGS
WITH AND WITHOUT ALFALFA HAY.**

During the winter of 1913-1914, from October 21, 1913, to January 27, 1914, 98 days, 7 lots of 10 pigs each were fed the following rations, with alfalfa hay in racks in addition:

- Shelled corn dry.
- Whole wheat dry.
- Whole wheat soaked.
- Ground wheat moistened.
- Ground wheat soaked.
- Whole rye soaked.
- Ground rye moistened.

Six other lots were fed the same rations as the first six lots without the alfalfa hay. This duplicated all excepting the last lot.

A full feed was given the pigs twice daily. As the relative results from the first group are almost identical with those from the second group, we shall discuss only the combined results of the two groups.

The rations are ranked below according to the rapidity of gain and the pounds of feed required to produce 100 pounds of gain. As the seventh lot was not duplicated it does not appear in these comparisons.

TABLE 1.—*Ranked according to rapidity of gain and feed for 100 pounds of gain.*

Ration	Daily gain per pig	Feed for 100 lbs. gain
	<i>Lbs.</i>	<i>Lbs.</i>
Ground wheat soaked.....	1.41	418
Ground wheat moistened	1.36	433
Shelled corn dry	1.11	479
Whole wheat soaked	1.05	514
Whole wheat dry	1.02	519
Whole rye soaked.....	.88	558

Grinding the wheat increased its feeding efficiency 21 per cent, or 1 bushel of ground wheat produced as much gain on the hogs as 1.21 bushels of whole wheat. The ground wheat also produced much faster gains than the whole wheat. Soaking the ground wheat increased its feeding efficiency about 4 per cent.

**Fig. 3.**—Hogs fattened on wheat. One bushel of ground wheat equals 1.21 bushels of whole wheat.

One bushel of ground wheat produced the same gain as 1.2 bushels of shelled corn.

One pound of ground wheat produced the same gain as 1.11 pounds of corn.

One bushel of shelled corn produced slightly more gain than one bushel of whole wheat.

Ground rye moistened ranked slightly lower than ground wheat moistened and higher than shelled corn in rapidity of gain and slightly lower than corn in the amount of grain required to produce 100 pounds of gain. This would make the feeding value of ground rye and shelled corn about equal per bushel for fattening hogs. Grinding the rye increased its feeding value 15 per cent and also increased the rate of gain.

Whole rye was unsatisfactory. It produced slow gains and required too much grain for the gains produced. One bushel of corn produced the same gain as 1.16 bushels of whole rye.

As the relative prices of wheat and corn vary greatly from year to year, we indicate below the cost of gains and profit per pig when the price of wheat is 70 cents per bushel, rye 50 cents per bushel, and corn 47 cents per bushel, and also 65 cents per bushel.

TABLE 2.—*Ranked according to economy of gain and profit per pig. Corn 47c, wheat 70c, and rye 50c per bushel. Hogs \$5.90 per 100 pounds.*

Ration	Cost of 100 lbs. of gain	Profit per pig
Shelled corn dry	\$3.97	\$2.11
Ground wheat soaked	4.84	1.46
Ground wheat moistened	5.00	1.21
Whole rye soaked	5.51	.34
Whole wheat soaked	5.92	Loss
Whole wheat dry	5.99	Loss

With these prices prevailing, corn was a more profitable feed than wheat or rye. The corn produced cheaper gains and more profit per pig than wheat or rye. However, when we assign to corn and hogs the prices prevailing while the experiment was in progress, which was 65 cents per bushel for corn and \$7.75 per 100 pounds for hogs, then corn does not hold first place in economy of gain or profit per pig, as is shown in the following comparisons:

TABLE 3.—*Ranked according to economy of gain and profit per pig. Corn 65c, wheat 70c, and rye 50c per bushel. Hogs \$7.75 per 100 pounds.*

Ration	Cost of 100 lbs. of gain	Profit per pig
Ground wheat soaked	\$4.84	\$4.02
Ground wheat moistened	4.99	3.70
Shelled corn dry	5.47	2.49
Whole rye soaked	5.50	1.97
Whole wheat soaked	5.92	1.91
Whole wheat dry	5.98	1.80

With these prices prevailing, ground wheat either soaked or moistened gave cheaper gains and more profit per pig than corn, but corn gave cheaper gains and more profit than whole wheat either dry or soaked.

If we should include the lot fed ground rye moistened, in this comparison, it would rank first in cost of 100 pounds of gain because of its relatively low price per bushel, and would rank ahead of corn and after ground wheat in profit per pig.

There was required considerably more whole soaked rye than whole soaked wheat or dry corn to produce 100 pounds of gain, but as rye was priced at 50 cents per bushel and wheat at 70 cents per bushel, the whole rye gave more profit than the whole wheat. The rate of gain was much less from rye than from wheat.

Soaking the ground wheat decreased the cost of 100 pounds of gain 15 cents, increased the profit per pig 32 cents, and raised the price received per bushel of wheat 4 cents, when hogs were worth \$7.75 per 100 pounds and wheat worth 70 cents per bushel.

Soaking the whole wheat decreased the cost of 100 pounds of gain 6 cents, increased the profit per pig 9 cents, and raised the price received for one bushel of wheat 1 cent, with prices as in the preceding paragraph.

Grinding the wheat and soaking it as compared with feeding whole wheat soaked decreased the cost of 100 pounds of gain \$1.08, increased the profit per pig \$2.11, and raised the price received for one bushel of wheat 21 cents.

Grinding the wheat and moistening it as compared with feeding dry whole wheat decreased the cost of 100 pounds of gain 99 cents, increased the profit per pig \$1.90, and raised the price received for one bushel of wheat 28 cents.

CORN AND ALFALFA COMPARED WITH CORN, SHORTS, AND ALFALFA FOR GROWING AND FATTENING HOGS.

On September 5, 1911, a lot of 64 pigs was divided into two uniform lots of 32 pigs each. The average weight of those in Lot 155 was 112 pounds and of those in Lot 156, 115 pounds. From this date until November 14, 10 weeks, each lot grazed on alfalfa pasture. Lot 155 was fed 3.34 pounds of ground corn daily per 100 pounds of the weight of the pigs, and Lot 156 was fed 3.30 pounds of a mixture of two-thirds corn and one-third shorts.

The pigs fed corn gained 0.05 pound more per head daily than those fed corn and shorts and ate 19 pounds less grain for 100 pounds gain. Using the prices given in this bulletin, shown on page 5, the pigs fed corn alone gave 1.6 times as much profit as those fed corn and shorts.

From November 14, 1911, to January 2, 1912, the two lots of hogs were kept in dry lots and were fed the grain rations indicated above with alfalfa hay in racks. The weather was so excessively cold that the gains on both lots were low and quite expensive. During this winter period of seven weeks, Lot 155 was fed 2.48 pounds of grain daily per 100 pounds of the weight of the pigs, and Lot 156 was fed 2.60 pounds. The pigs fed the mixture consisting of 2 parts corn and 1 part shorts gained 0.06 pound more per head daily than those fed corn alone. The pigs getting the former ration required 2 pounds more grain to produce 100 pounds of gain than those getting the ration of corn. The profit per pig was 32 cents for those fed corn alone and 0.4 cent for those fed corn and shorts.

If we combine the summer and the winter periods, we find that the average daily gain was the same on both lots, and that there were required 16 pounds more of the corn and shorts than of the corn alone to produce 100 pounds of gain. The profit on the pigs fed corn alone was almost twice as much as on those fed corn and shorts. This is considering corn worth 47 cents per bushel, shorts \$24 per ton, and hogs \$5.90 per 100 pounds. If the shorts had cost \$15.17 per ton it would have given the same profit as corn at 47 cents per bushel in this test. On this basis, corn is worth 75 cents per bushel when shorts is worth \$24 per ton.

ALFALFA TEA AND ALFALFA TEA GROUNDS IN A RATION FOR WINTERING SHOATS.

On February 8, 1912, 20 fall shoats weighing about 50 pounds each were divided into two uniform lots of 10 pigs each. Another lot of 26 pigs weighing 70 pounds each was divided into two uniform lots of 13 pigs each.

The grain ration for all lots was 3 parts corn and 1 part shorts. Chopped alfalfa was kept in racks where each lot had access to it at all times. The feed for Lot 157 was made into a thick slop with warm water. The feed for Lot 158 was wet with tea made by stewing chopped alfalfa for one hour. The alfalfa used for making tea for each feed amounted to about 20 per cent of the grain ration. The amount of liquid put into the feed of Lot 157 and of Lot 158 was the same. These two lots were given all they would eat, but both lots were kept on the same amount of feed. All feed was the same for the two lots except that the feed for Lot 157 was wet with warm water, while the feed for Lot 158 was wet with warm alfalfa tea.

The rations for Lots 159 and 160 were identical excepting that Lot 160 was fed chopped alfalfa which had been stewed for an

hour and the tea drawn off, and Lot 159 was fed the same amount of chopped alfalfa unsteamed. In both lots the grain was fed mixed with alfalfa and moistened with warm water. The feed for Lots 159 and 160 was identical excepting that Lot 159 was fed alfalfa with the grain and Lot 160 was fed the same amount of alfalfa after it had been stewed an hour and the tea drawn off. The feed for each lot was wet with warm water.

Lots 157 and 158 should not be compared with Lots 159 and 160. The pigs in the first two lots were not of the same size as those in the latter two lots. Also, the first two lots were fed more in proportion to their weight than the latter two lots.



Fig. 4.—Three lots of fall pigs eating chopped alfalfa. They are Lots 3, 4, and 1 of the alfalfa tea experiment.

The pigs fed alfalfa tea gained a little faster with less grain for 100 pounds of gain than the pigs that did not receive tea. Also, the pigs fed the alfalfa tea grounds made faster gains with less grain for 100 pounds of gain than those fed alfalfa not stewed. The tea grounds had a more beneficial effect than the tea. The relative gains of Lot 160 and Lot 159 were 100 and 84 respectively; the relative gains of Lot 158 and Lot 157 were 100 and 94 respectively.

The results of this one experiment indicate that there is some value in stewed alfalfa over alfalfa not stewed. The tea from 100 pounds of stewed alfalfa save 47 pounds of corn. The tea grounds from 100 pounds of stewed alfalfa saved 67 pounds of corn. The stewing of 100 pounds of alfalfa hay saved 2 bushels of corn and increased the rate of gains. Two bushels of corn at 47 cents per bushel are worth 94 cents; or at 60 cents per bushel, the 2 bushels are worth \$1.20.

A second test was conducted with fall pigs during the winter of 1913-1914. A lot of 28 pigs was divided into two uniform lots of 14 pigs each on January 13, 1914. The average weight of the pigs was 56 pounds. They were kept in the test until April 7, 1914, when their average weight was 103 pounds.

Lot 161 was fed a ration of 90 parts ground corn and 10 parts chopped alfalfa hay; Lot 162 was fed the same amount of ground corn as Lot 161 and all the stewed alfalfa the pigs would eat. The grain and alfalfa fed to Lot 161 were mixed and moistened with hot water. For Lot 162 the alfalfa was stewed and both the tea and the grounds mixed with the grain. This lot ate about a half more alfalfa than the lot that ate the alfalfa that had not been stewed.

The two lots made nearly the same gain with a slight advantage in favor of the alfalfa tea lot. This lot ate 12 pounds less grain and 35 pounds more alfalfa to produce 100 pounds of gain than the other lot. The cost of 100 pounds of gain on the pigs fed tea was 7 cents higher and the profit per pig was 7 cents less than on the pigs fed the alfalfa without stewing. The results of this test do not indicate that the value of the alfalfa was increased by stewing.

The results of the two tests would not warrant the farmer in going to much, if any, expense to stew alfalfa for hogs.

SUMMARY OF AVERAGES AND ANNUAL FINANCIAL STATEMENTS.

An accurate record is kept of all grain and alfalfa fed to hogs during the year. The hogs graze on about 40 acres of alfalfa pasture but consume only about one-half of the alfalfa. A rental of \$5 per acre is charged to the hogs. An inventory of the hogs by weight is taken March 1 each year. From the data thus obtained the following annual statements are compiled. These statements give a fair idea of the cost of producing pork on a Nebraska farm, only that the farmer should produce pork cheaper since he is working entirely for profits and is not necessarily feeding hogs the more costly or less profitable rations and does not suffer the loss occasioned by frequent weighings, and other disturbing factors incident to experimental work.

TABLE 4.—*Summary of averages. Corn compared with corn and shorts, corn and barley, corn and emmer, corn and wheat, and corn and tankage.*

Ration	Corn	Corn, shorts	Corn, barley	Corn, emmer	Corn	Corn, wheat	Corn	Corn, tank-age
No. tests conducted.....	10	8	8	3	4	4	7	7
No. pigs tested	168	132	132	84	64	64	162	162
Daily gain per pig, lbs.	.94	1.19	1.10	1.14	1.30	1.22	1.17	1.45
Feed for 100 lbs. gain, lbs.	436	478	532	529	501	470	511	459
Cost of 100 lbs. gain.....	\$3.66	\$4.07	\$4.48	\$3.95	\$4.01	\$4.53	\$4.26	\$4.08
Profit per pig.....	1.70	1.34	1.26	1.38	2.33	1.71	1.83	2.45

Corn vs. Corn and Shorts—Average of 10 tests.

Corn tied in rapidity of gain.
 Corn required 3 lbs. more feed for 100 lbs. gain.
 Corn cost 41 cents less for 100 lbs. gain.
 Corn gave 36 cents more profit per pig.
 Corn vs. Corn and Barley—Average of 8 tests.
 Corn gave 0.09 lb. the faster daily gain.
 Corn required 55 lbs. less feed for 100 lbs. gain.
 Corn cost 44 cents less for 100 lbs. gain.
 Corn gave 52 cents more profit per pig.
 Corn vs. Corn and Emmer—Average of 3 tests.
 Corn gave 0.19 lb. the faster daily gain.
 Corn required 52 lbs. less feed for 100 lbs. gain.
 Corn cost 53 cents less for 100 lbs. gain.
 Corn gave 57 cents more profit per pig.

Corn vs. Corn and Wheat—Average of 4 tests.

Corn gave 0.08 lb. the faster gain.
 Corn required 31 lbs. more feed.
 Corn cost 52 cents less for 100 lbs. gain.
 Corn gave 62 cents more profit per pig.
 Corn vs. Corn and Tankage—Average of 7 tests.
 Corn gave 0.28 lb. less daily gain.
 Corn required 52 lbs. more feed for 100 lbs. gain.
 Corn cost 18 cents more per 100 lbs. gain.
 Corn gave 62 cents less profit per pig.

A ration of corn and alfalfa has been more profitable than any other ration in this comparison, excepting corn and tankage. Several of the tests with tankage were made under conditions which we believe unduly favored the tankage lots.

STATEMENT 1.—Pounds of pork produced March 1 to March 1 during the following years:

Year	1911-1912		1912-1913		1913-1914	
	Dr.	Cr.	Dr.	Cr.	Dr.	Cr.
March 1. To lbs. pork on hand	21,195					
To lbs. pork received during year	1,800		39,202		38,810	
By lbs. pork sold during year		60,786		71,714	200	56,436
March 1. By lbs. pork on hand		39,202		38,810		39,575
To gain in lbs. pork during year	76,993		71,322		57,001	
	99,988	99,988	110,524	110,524	96,011	96,011

Pork Production.

STATEMENT 2.—Profit on hogs, considering only cost of feed, from March 1 to March 1 of the following years.*

Year	1911-1912		1912-1913		1913-1914	
	Dr.	Cr.	Dr.	Cr.	Dr.	Cr.
To cost of grain during the year	\$3,614.09	.....	\$3,294.32	.....	\$2,661.16	.....
To cost of alfalfa hay during the year	140.67	.....	94.38	.....	81.60	.....
To cost of pasture during the year	200.00	.....	200.00	.....	200.00	.....
By income from hog sales .....	.....	\$3,574.37	.....	\$5,290.91	.....	\$4,677.39
By value of net gain or loss March 1 (market price) † .....	.....	1,062.41	29.40	.....	.....	44.07
To labor and profit	652.02	.....	1,672.81	.....	1,778.70	.....
	\$4,636.78	\$4,636.78	\$5,290.91	\$5,290.91	\$4,721.46	\$4,721.46

* For prices of feed and hogs, see Statement 6.

† On March 1, 1912, there were 18,007 pounds of pork more on hand than on March 1, 1911. This at \$5.90, the market price at North Platte on March 1, 1912, gives a credit of \$1,062.41. On March 1, 1913, there were 382 pounds less of pork on hand than on March 1, 1912. This at \$7.50, the market price at North Platte on March 1, 1913, gives a debit of \$29.40. On March 1, 1914, there were on hand 565 more pounds of pork than on March 1, 1913. This at \$7.80, the market price at North Platte on March 1, 1914, gives a credit of \$44.07.

Pork Production.

STATEMENT 3.—Profit on hogs, considering corn worth 60 cents per bushel and hogs \$5.90 per 100 pounds, from March 1 to March 1 of the following years:

Year.....	1911-1912		1912-1913		1913-1914	
	Dr.	Cr.	Dr.	Cr.	Dr.	Cr.
March 1. To value of pork on hand at \$5.90	\$1,250.50		\$2,312.92		\$2,301.59	
To cost of feed during year	3,984.76		3,588.70		2,839.51	
March 1. By income from hog sales, at \$5.90		\$5,899.29		\$6,520.92		\$5,604.65
To labor and profit	664.03		619.30		523.55	
	\$5,899.29	\$5,899.29	\$6,520.92	\$6,520.92	\$5,664.65	\$5,664.65
By interest, depreciation, and upkeep (Statement 5) 1911-1912 1912-1913 1913-1914						
To labor and profit			\$348.17	\$406.44	\$383.29	
Cost of all feed for 100 lbs. of grain			318.86	212.86	140.26	
			5.175	5.03	4.98	

Pork Production.

STATEMENT 4.—*Profit on hogs, considering corn worth 47 cents per bushel and hogs \$5.90 per 100 pounds, from March 1 to March 1 of the following years:*

Year	1911-1912		1912-1913		1914-1914	
	Dr.	Cr.	Dr.	Cr.	Dr.	Cr.
March 1. To value of pork on hand, at \$5.90	\$1,250.50		\$2,312.92		\$2,301.59	
To cost of feed during the year	3,291.24		2,961.71		2,571.06	
March 1. By income from hog sales, at \$5.90		\$5,899.29		\$6,520.92		\$5,064.65
To labor and profit	1,357.45		1,246.29		792.00	
	\$5,899.29	\$5,899.29	\$6,520.92	\$6,520.92	\$5,664.65	\$5,664.65

	1911-1912	1912-1913	1913-1914
By interest, depreciation, and upkeep (Statement 5)	\$327.77	\$387.63	\$383.29
To labor and profit	1,029.68	858.66	408.71
Cost of all feed for 100 lbs. of gain	4.275	4.15	4.52

STATEMENT 5.—Interest, depreciation, and upkeep per year for the following years:

Year.....	1911-1912	1912-1913	1913-1914
March 1.			
6 per cent on value of hogs on hand at \$5.90.....	\$75.03	\$138.78	\$138.10
6 per cent on cost of grain for 6 months (corn 60c)	113.14	107.66	85.19
6 per cent on inventory in buildings (\$1,000)	60.00	60.00	60.00
10 per cent depreciation and upkeep on buildings	100.00	100.00	100.00
	\$348.17	\$406.44	\$383.29

Pork Production.

STATEMENT 6.—Pounds of grain eaten per 100 pounds of gain and cost of 100 pounds of gain with corn at various prices; also average selling price of hogs from March 1 to March 1 of the following years:

Year	1911-1912	1912-1913	1913-1914
Pounds of grain for 100 lbs. of gain.....	436	414	405
Cost of feed (alfalfa and grain) for 100 lbs. of gain—Corn per bushel 70 cts. . .	\$5.86	\$5.63	\$5.34
60 cts. . .	5.17	4.96	4.98
50 cts. . .	4.48	4.29	4.62
47 cts. . .	4.28	4.15	4.51
Average selling price of hogs per 100 lbs.....	7.52	7.38	8.29

STATEMENT 7.—Total amount of feed eaten by the hogs from March 1 to March 1 of the following years; also average cost of feed during these years:

Year—Price per bushel or ton.....	1911-1912	Price	1912-1913	Price	1913-1914	Price
Bushels of corn	5,334	\$0.60	4,823	\$0.60	2,065	\$0.65
Bushels of wheat	127	.70	10.4	.70	1,452	.70
Bushels of rye	42.5	.50	.....	.....	400	.50
Bushels of oats	30	.40	.....	.....	149	.35
Bushels of barley .....	.....	.....	.....	.....	6	.40
Bushels of cane	8.75	.75	.....	.....	.....	.....
Tons of shorts	5.8	26.00	5.97	26.00	.....	26.00
Tons of oil meal	2.73	30.00	1.02	30.00	.51	30.00
Tons of alfalfa meal	3.60	15.00	3.04	15.00	.61	15.00
Tons of cottonseed cake .....	.....	.....	.33	30.00	.....	.....
Pounds of bone meal	96	40.00	.....	.....	.....	.....
Pounds of tankage	1,255	42.00	3,840	45.00	860	45.00
Tons of cut alfalfa	7.65	10.00	7.75	10.00	6	10.00
Tons of alfalfa hay	3.24	8.00	2.11	8.00	2.7	8.00

The bulk of the feed was corn and alfalfa, excepting in 1913-1914 when wheat replaced most of the corn. Only a very small amount of mill feeds was used. The 40 acres of alfalfa pasture produced 2.25 tons of hay per acre. This is 54 per cent as much as the fields not pastured.

(3-11-'13—20M.)

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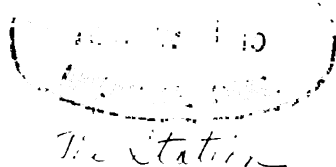
A HANDBOOK OF NEBRASKA GRASSES

WITH ILLUSTRATED KEYS FOR THEIR IDENTIFICATION, TOGETHER
WITH A GENERAL ACCOUNT OF THEIR STRUCTURE AND
ECONOMIC IMPORTANCE.

• BY E. MEAD WILCOX, GEORGE K. K. LINK, AND VENUS W. POOL.

DISTRIBUTED APRIL 1, 1915.

LINCOLN, NEBRASKA
U. S. A.



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A HANDBOOK OF NEBRASKA GRASSES.

BY E. MEAD WILCOX, GEORGE K. K. LINK, AND VENUS W. POOL.*

INTRODUCTION.

The true grasses belong to the one family Poaceae, often called Gramineae, and constitute a very well defined natural group of plants. This family comprises upward of 3,000 species distributed among about 300 genera. From the economic point of view the family is of supreme importance thru the fact that here belong the cereals, which supply a large part of the food of man, and the forage grasses which are so important as feed for our domesticated animals.

The genera and species are for the most part separated by artificial characters—a fact which renders their study and identification extremely difficult even for the expert. The experience of the authors has convinced them that much of this difficulty is to be credited to the “keys” found in our common manuals. Theoretically a key is intended to assist one in properly identifying a plant, but actually many of the keys, upon close inspection, are found to contain so many vague and contradictory statements that they can be depended upon only by the expert who, on account of his working knowledge, makes slight use of the keys.

It occurred to the senior author some years ago that an illustrated key might solve many of these difficulties. An accurate illustration conveys a more definite idea of any particular structure and leaves less room for doubt than any number of words. In fact, the serious and annoying inaccuracies of most keys to the grasses became more and more apparent as the work of preparing the illustrations progressed. The authors are fully convinced that illustrated keys of the type here employed will prove useful in many other groups of plants.

The nomenclature here employed is largely that of the seventh edition of Gray's Manual—tho our purpose has not been to insist upon any particular name but to provide means whereby the student can with some certainty attach to any given plant some one name which has been properly authorized.

* Resigned November 1, 1911.

The present key includes most of the species known to occur in Nebraska, tho a few of minor importance and very restricted distribution have been omitted. There are provided also some data on the economic value of certain of the most important species.

The illustrations for the grass keys have been drawn expressly for this publication. They are derived in part from actual authentic specimens and in part redrawn in modified form from various manuals and monographs. The authors have made free use of the manuals, monographs, etc., included in the Bibliography and take this opportunity to commend these publications to the attention of all who wish to learn more of our common grasses. It is hoped that the keys here presented will facilitate the study of the grass flora of Nebraska by farmers and students.

STRUCTURE OF GRASSES.

The grasses are herbs (rarely shrubs or trees) with extensive fibrous root-systems. They may be perennials with rhizomes (fig. 1, A) or sympodia (fig. 1, B), or annuals with sympodia. The extensive system of rhizomes enables these plants to form a "sod" and may render their eradication difficult. The primary root soon disappears, its function being taken over by numerous secondary roots which arise from the nodes.

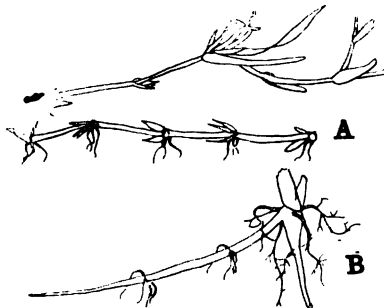


Fig. 1.



They have cylindrical stems with hollow internodes and generally swollen closed nodes (fig. 2). In some species, such as maize and sorghum, the stems are filled with pith.

The leaves are 2-ranked, narrow, parallel-veined (fig. 3) and consist of two parts, the sheath (fig. 3, C) and the blade, (fig. 3, A). The sheath with its margins over

lapping, or, rarely grown together, envelopes the internode for more or less of its length (fig. 4). At the junction of the sheath and the blade, on the inside, is an erect membranaceous, hyaline, or hairy appendage, called the ligule (fig. 3, B).

The flowers are grouped in spicate, racemose, or paniculate inflorescences which in turn are composed of partial inflorescences, the spikelets (fig. 6).

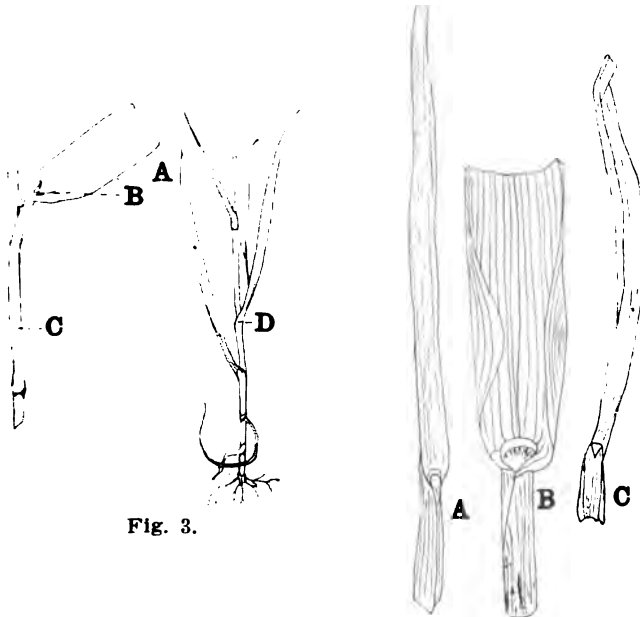


Fig. 3.

Fig. 4.

Figure 5 shows diagrams of a typical spike, raceme, and panicle. In an inflorescence, the branches are generally subtended by bracts (in grasses such bracts are wanting). In a spike (fig. 5, B) the flowers are sessile on an elongated main axis, the rachis; in a raceme (5, A) the flowers are stalked and borne on the rachis, in a panicle (5, C) the rachis bears racemes laterally.

The flowers, generally perfect (rarely unisexual) (figs. 6 and 7), are arranged in spikelets which consist of a shortened axis, the rachilla (figs. 6, A, and 8, A), and 2 or more 2-ranked bracts (figs. 7, A, and 8).

Usually the lowest bracts are empty and are then called glumes (fig. 8, F). Sometimes the glumes are absent or there may be 3-4 glumes. In the axil of each succeeding bract, the lemma (fig. 8, E) is a flower (fig. 8, B, C), which is subtended and usually enveloped by a bract, the palea (fig. 8, D). The

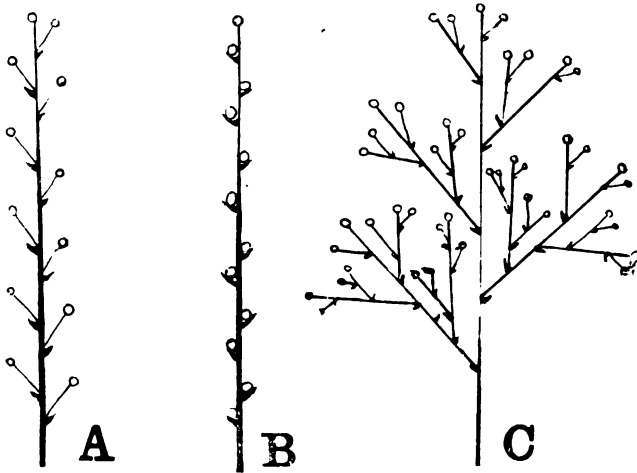


Fig. 5.



Fig. 6.



Fig. 7.

lemma often bears a stiff bristle, the awn, which is covered by backwardly turned hairs.

A flower consists of 3 stamens (sometimes 1, 4, or 6) (fig. 7, B), an ovary (fig. 7, D and 8, B), composed of three carpels which bear two feathery papillose stigmas (fig. 7, C), and the lodicules.

The fruit of grasses is called a caryopsis, having the pericarp and seed coat intimately united. The embryo lies in contact with the endosperm (fig. 9, A) by means of its cotyledon. The part of the cotyledon next to the endosperm is the scutellum (fig. 9, C), serving as an absorbent organ in germination. The starch, oil, and protein of the endosperm and embryo render the fruit of grasses of high economic value.

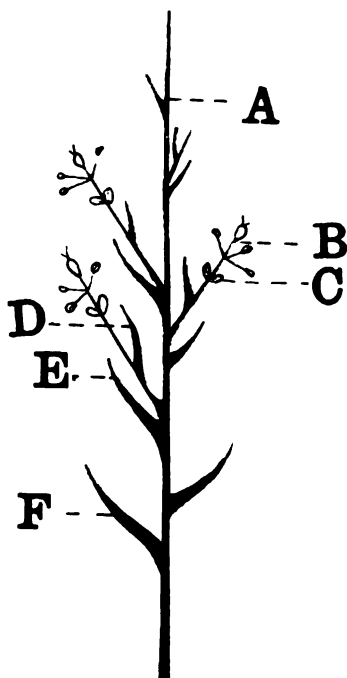


Fig. 8.

DIRECTIONS FOR USE OF THE KEYS.

A good hand lens will be found a necessity in the study of the grasses. The beginner should carefully study the statements under "Structure of Grasses" (p. 6). With a specimen of the grass before him he is then ready to begin the work of identification. As an illustration we may select the awnless brome grass, *Bromus inermis*.

We begin with the "Tribe Key to the Grasses" (p. 11). At the top of the page are found three lines, each describing a cer-

tain group of grasses. We must decide which of the three lines best describes our grass.

Since in our grass the spikelets are in a panicle, like the extreme right-hand drawing of figure 10, we refer next to the lines below marked "3." We must here decide whether the spikelet in our grass has one or two or more flowers. Since this spikelet evidently has more than one flower, as shown in the extreme right-hand drawing of figure 12, we turn next to the lines marked "7" (p. 14).

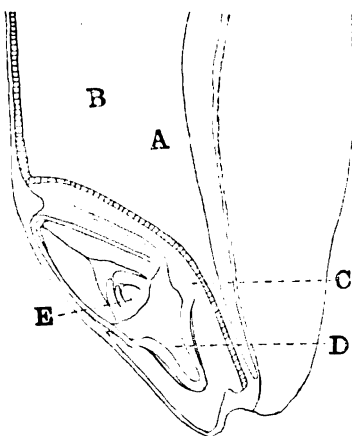


Fig. 9.

Here our decision is required as to the character and location of the awn on the lemma. By consulting the two figures we see plainly that this grass belongs to the tribe FESTUCEAE (p. 44).

Our plant being "erect" we turn to "2" below. The rachilla is found to be "naked," *i. e.*, without any silky hairs, so we refer to "3." With the aid of a lens the "lemma" must be examined to determine the number of its "nerves" or veins. Evidently it has "5-many," as shown in the right-hand drawings of figure 65, and hence we turn to "10" (p. 49).

Our plant is described by the second line under "10" so that we turn to "11" (p. 49). The lemma will be found to be "rounded on the back," which takes us to "14" (p. 50). The lemma being "naked at the base," we go to "15" (p. 51).

Here we find that the second line under "15" describes our grass and we turn to "16" below.

The exact location of the style with reference to the tip of the ovary must next be determined. This brings us to the genus *Bromus*.

To determine the exact species of *Bromus* we must refer to the key to the species of this genus (p. 60) and proceed in the above manner to find the name of the plant before us.

TRIBE KEY TO THE GRASSES.

	FIG.	PAGE
1. Spikelets sessile, alternating on opposite sides of the rachis HORDEAE	10	66
1. Spikelets sessile or somewhat pedicellate, on one side of the rachis 2	10	
1. Spikelets sessile, forming a compact head; or compoundly pedicellate, forming a panicle.....3	10	12

Figure 10.



2. Glume keeled	CHLORIDEAE	11	41
2. Glume not keeled	PANICEAE	11	15

Figure 11.

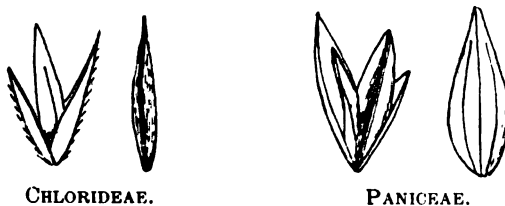
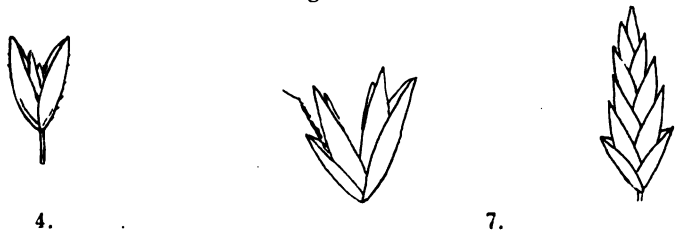


	FIG.	PAGE
3. Spikelets with one perfect flower.....	4	12
3. Spikelets with two to many flowers.....	7	14

Figure 12.



4. Spikelets, at least some of them, imbedded in the rachis	MAYDEAE	
[<i>Tripsacum dactyloides</i> is the only species of this tribe included in this key].....	13	94
4. Spikelets free, none imbedded.....	5	11

Figure 13.



MAYDEAE (*Tripsacum dactyloides*).

5.

	FIG.	PAGE
5. Spikelets in pairs, one sessile and perfect, the other pedicellate and staminate, empty or reduced to the pedicle ANDROPOGONEAE	14	14
5. Spikelets single 6	14	

Figure 14.



6. Glumes none ORYZEAE	15	22
6. Glumes 2 AGROSTIDEAE	15	24
6. Glumes 3 PANICEAE	15	15
6. Glumes 4 PHALARIDEAE	15	23

Figure 15.

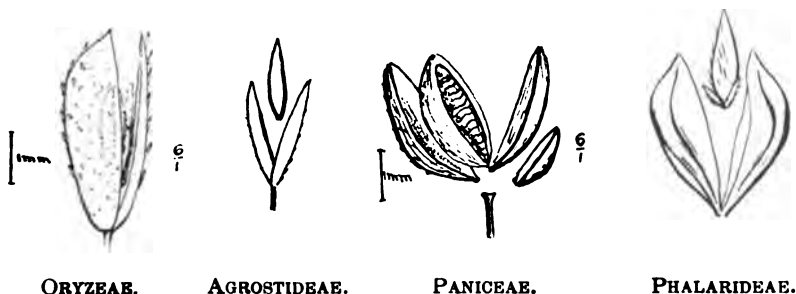
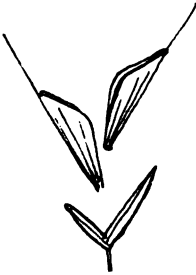


		FIG.	PAGE
7. Awn, if present, straight and arising at or near the apex of the lemma	FESTUCEAE	16	44
7. Awn always present, straight or twisted and arising midway between the base and the apex..	AVENEAE	16	39

Figure 16.



FESTUCEAE.

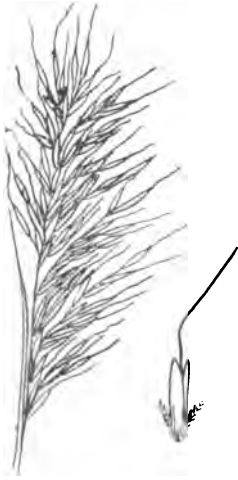


AVENEAE.

ANDROPOGNEAE.

1. Spikelets arranged in a panicle.....	2	
1. Spikelets arranged in silky racemes.....	3	15
2. Pedicellate spikelet wanting.....		
..... <i>Sorghastrum nutans</i>	17	92
2. Pedicellate spikelet present.....		
..... <i>Andropogon halepensis</i>	17	79

Figure 17.



Sorghastrum nutans.



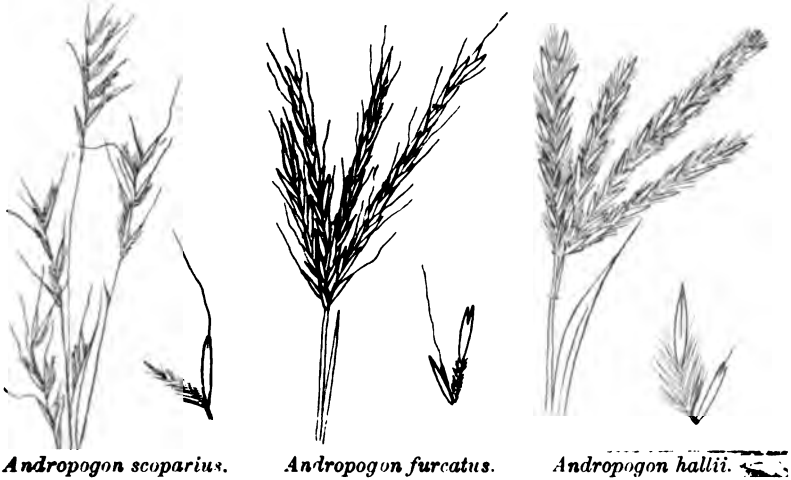
Andropogon halepensis.



3.

	FIG.	PAGE
3. Racemes single..... <i>Andropogon scoparius</i>	18	79
3. Racemes in pairs	4	
4. Fourth glume with long twisted awn.....		
..... <i>Andropogon furcatus</i>	18	79
4. Fourth glume with short straight awn.....		
..... <i>Andropogon hallii</i>	18	79

Figure 18.



PANICEAE.

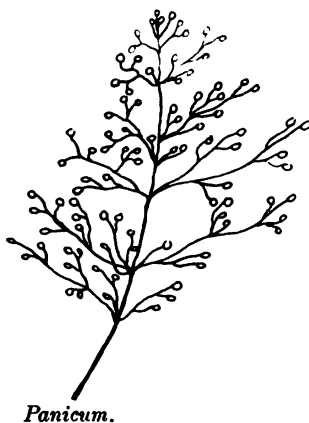
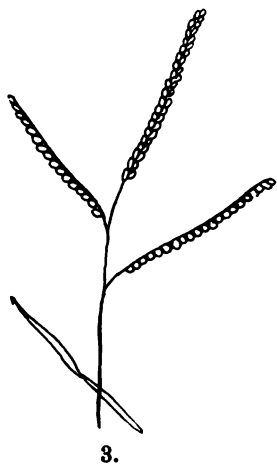
1. Spikelets not surrounded by bristles nor spines...	2	19	16
1. Spikelets surrounded by prominent bristles or spines	5	19	17

Figure 19.



	FIG.	PAGE
2. Spikelets in a one-sided spike or raceme.....3	20	
2. Spikelets in a panicle..... <i>Panicum</i>	20	19

Figure 20.



3. Racemes in terminal digitate whorls.....		
..... <i>Digitaria sanguinalis</i>	21	84
3. Racemes scattered	4	17

Figure 21.

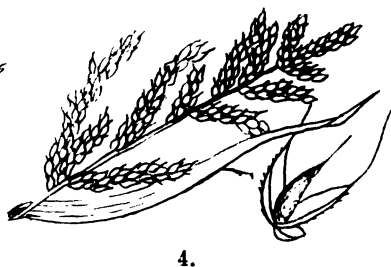
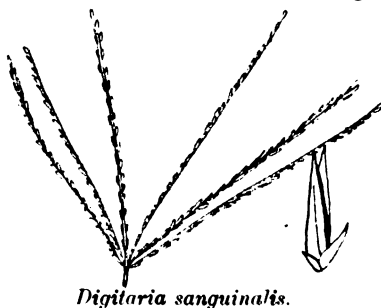
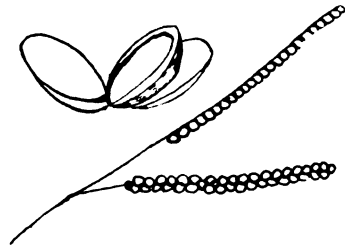


		FIG.	PAGE
4. Glumes awned.....	<i>Echinochloa crus-galli</i>	22	85
4. Glumes not awned.....	<i>Paspalum stramineum</i>	22	90

Figure 22.



Echinochloa crus-galli.



Paspalum stramineum.

5. Spikelet surrounded by thickened spines.....			
.....	<i>Cenchrus tribuloides</i>	23	83
5. Spikelet surrounded by bristles.....	6	23	18

Figure 23.



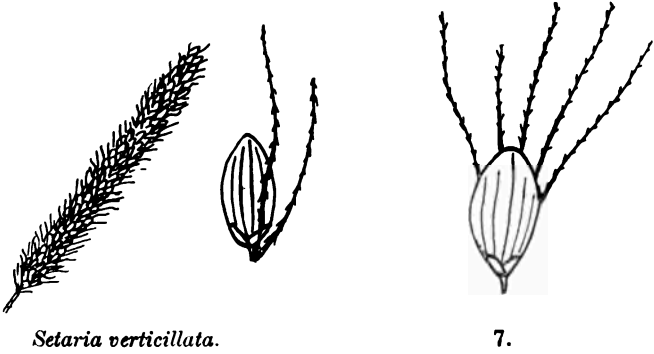
Cenchrus tribuloides.



6.

	FIG.	PAGE
6. Bristles downwardly barbed.....		
..... <i>Setaria verticillata</i>	24	92
6. Bristles upwardly barbed.....	7	24

Figure 24.

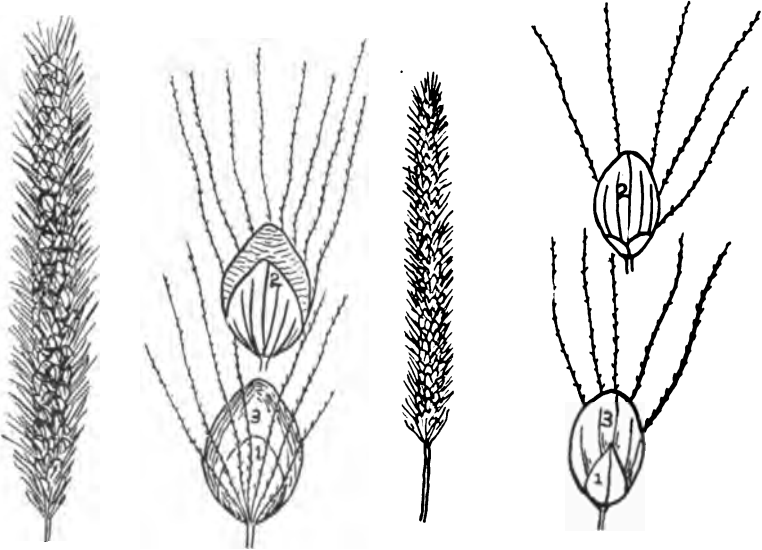


Setaria verticillata.

7.

7. Second glume shorter than the third.....		
..... <i>Setaria glauca</i>	25	92
7. Second glume equaling the third....	<i>Setaria viridis</i>	25 92

Figure 25.



Setaria glauca.

Setaria viridis.

PANICUM.

	FIG.	PAGE
1. Spikelets pointed at the tip.....	2	26
1. Spikelets rounded at the tip.....	4	26

Figure 26.



2. First glume not over one-fourth the length of the spikelet.....	<i>Panicum dichotomiflorum</i>	27	89
2. First glume about one-half the length of the spikelet		27	20
2. First glume two-thirds to three-fourths the length of the spikelet....	<i>Panicum virgatum</i>	27	90

Figure 27.



Panicum dichotomiflorum.



3.



Panicum virgatum.

	FIG.	PAGE
3. Spikelets 2.5 mm. long or less; blades not crowded toward the base..... <i>Panicum capillare</i>	28	89
3. Spikelets 2.5-5.0 mm. long; blades crowded toward the base	4	28
4. Spikelets 2.6-3.3 mm. long; panicles erect..... <i>Panicum barbipulvinatum</i>	28	89
4. Spikelets 4.5-5.0 mm. long; panicles drooping <i>Panicum miliaceum</i>	28	90

Figure 28.

*Panicum capillare.**Panicum barbipulvinatum.**Panicum miliaceum.*

5. Spikelets less than 2 mm. in length.....	6	
5. Spikelets more than 2.5 mm. in length.....	7	21
6. Spikelets 1.8-1.9 mm. long; blades with long spreading hairs on the upper surface; first glume triangular, one-third to one-half length of spikelet..... <i>Panicum praecocius</i>	29	90
6. Spikelets 1.6-1.8 mm. long; blades with short appressed hairs on the upper surface; first glume, not triangular, about one-third length of spikelet..... <i>Panicum huachucae</i>	29	89

Figure 29.

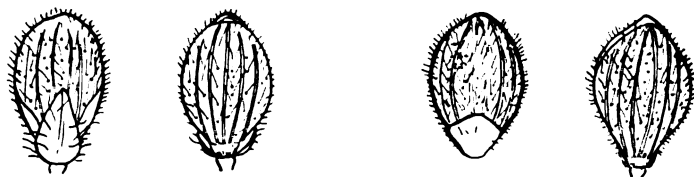
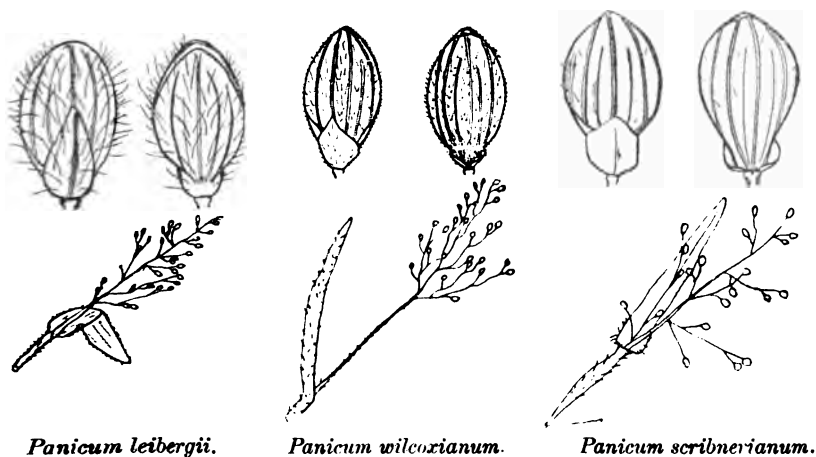
*Panicum praecocius.**Panicum huachucae.*

	FIG.	PAGE
7. First glume one-half the length of the spikelet.... <i>Panicum leibergii</i>	30	89
7. First glume less than one-third the length of the spikelet 8	30	
8. Spikelets densely hairy.. <i>Panicum wilcoxianum</i>	30	90
8. Spikelets sparsely hairy to smooth..... <i>Panicum scribnerianum</i>	30	90

Figure 30.



ORYZEAE.

	FIG.	PAGE
1. Upper spikelets pistillate, some long-awned; lower spikelets staminate, awnless.... <i>Zizania aquatica</i>	31	94
1. Spikelets all alike and awnless.....2		
2. Spikelets 2.5-3.0 mm. long.... <i>Leersia virginica</i>	31	88
2. Spikelets 4-5 mm. long..... <i>Leersia oryzoides</i>	31	88

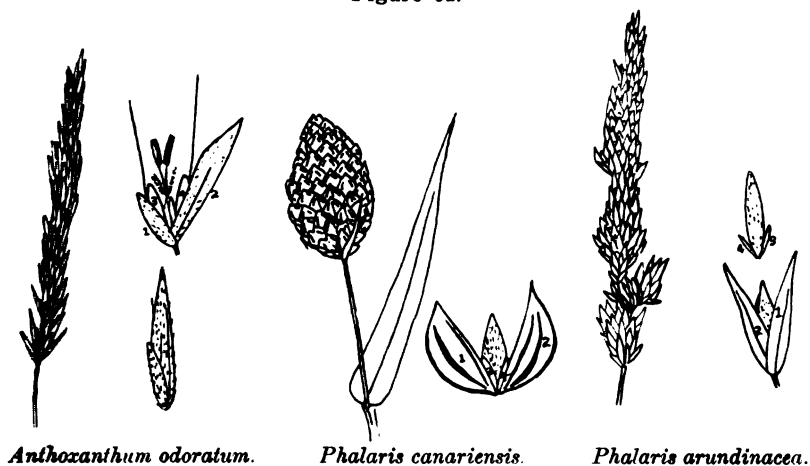
Figure 31.

*Zizania aquatica.**Leersia virginica.**Leersia oryzoides.*

PHALARIDEAE.

	FIG.	PAGE
1. Third and fourth glumes awned upon the back.		
. <i>Anthoxanthum odoratum</i>	32	79
1. Third and fourth glumes rudimentary, not awned. 2		
2. First and second glumes with wing-like keels.		
. <i>Phalaris canariensis</i>	32	90
2. First and second glumes not winged.		
. <i>Phalaris arundinacea</i>	32	90

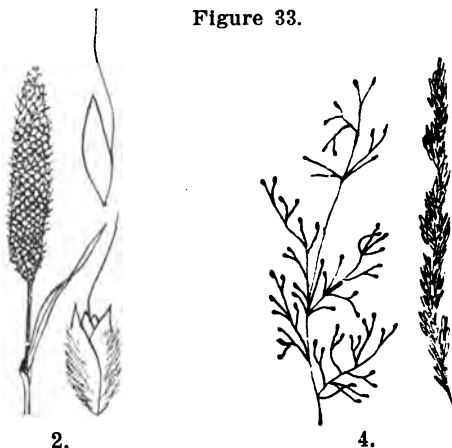
Figure 32.



AGROSTIDEAE.

	FIG.	PAGE
1. Spikelets in a close spike.....	2	33
1. Spikelets in an open or contracted panicle.....	4	33

Figure 33.



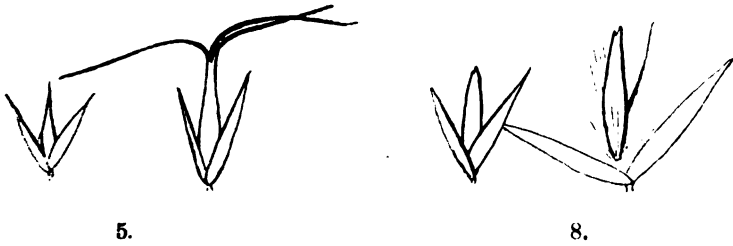
2. Glumes awnless.....	<i>Alopecurus geniculatus</i>	34	79
2. Glumes awned	3		
3. Glumes with a long slender awn.....			
.....	<i>Polypogon monspeliensis</i>	34	91
3. Glumes with a short abrupt awn..	<i>Phleum pratense</i>	34	90

Figure 34.

*Alopecurus geniculatus.**Polypogon monspeliensis.**Phleum pratense.*

	FIG.	PAGE
4. Lemma awn-pointed or with terminal awn..	5	35
4. Lemma awnless or with a dorsal awn.....	8	35 27

Figure 35.



5. Rachilla prolonged behind the palea.....		
.....	<i>Brachyelytrum erectum</i>	36 81
5. Rachilla not prolonged behind the palea.....	6	36 26

Figure 36.

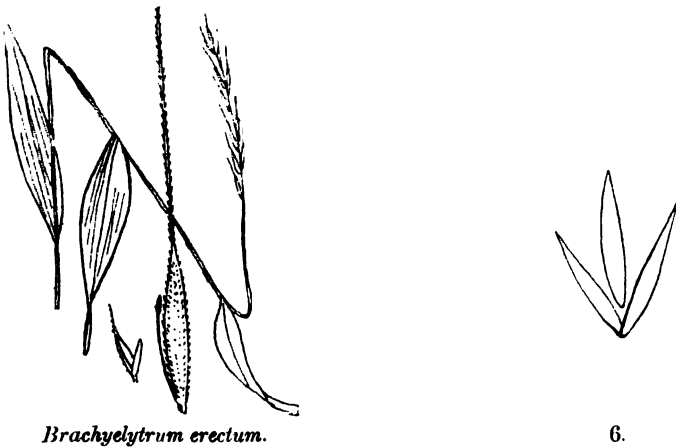


	FIG.	PAGE
6. Lemma long and narrow with three awns.....		
..... <i>Aristida</i>	37	30
6. Lemma narrow with one long twisted awn....		
..... <i>Stipa</i>	37	32
6. Lemma short and narrow, awn-pointed or with a slender awn	<i>Muhlenbergia</i>	37 33
6. Lemma broad, the short awn falling soon after flowering	7 37	

Figure 37.



7. Lemma smooth.....	<i>Oryzopsis micrantha</i>	39	89
7. Lemma with long silky hairs....	<i>Eriocoma cuspidata</i>	39	86

Figure 38.

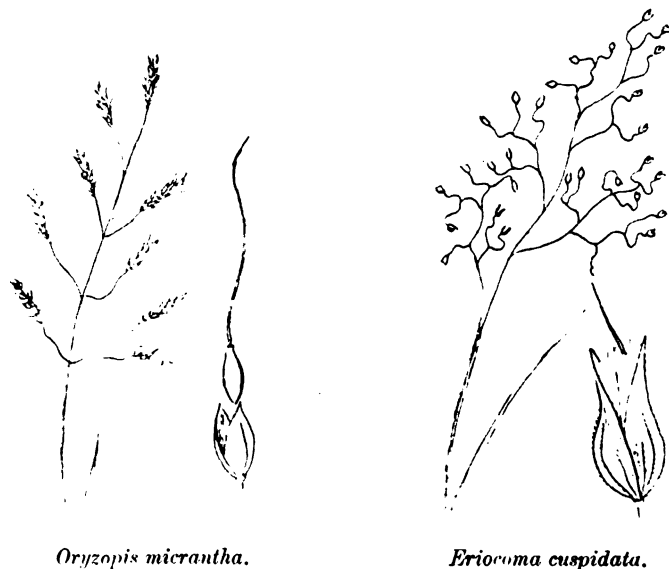


	FIG.	PAGE
8. Lemma with long basal hairs.....	9	39
8. Lemma without basal hairs.....	10	39 28

Figure 39.



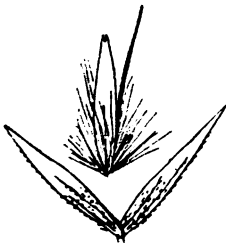
9.



10.

9. Lemma awned; basal hairs abundant.....		
..... <i>Calamagrostis</i>	40	35
9. Lemma awnless; basal hairs not abundant.....		
..... <i>Calamovilfa longifolia</i>	40	83

Figure 40.



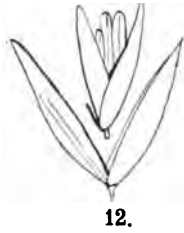
Calamagrostis.



Calamovilfa longifolia.

	FIG.	PAGE
10. Flower not plainly pedicellate.....	11	41
10. Flower plainly pedicellate.....	12	41 29

Figure 41.



11. Lemma shorter than or equal to the glumes.....		
..... <i>Agrostis</i>	42	36
11. Lemma longer than one or both of the glumes....		
..... <i>Sporobolus</i>	42	37

Figure 42.



	FIG.	PAGE
12. Panicle contracted at maturity; first glume shorter than the second.. <i>Cinna arundinacea</i>	43	83
12. Panicle open at maturity; first glume equal to the second..... <i>Cinna latifolia</i>	43	83

Figure 43.



Cinna arundinacea.



Cinna latifolia.

ARISTIDA.

	FIG.	PAGE
1. Awns twisted at the base into a spiral column.... <i>Aristida tuberculosa</i>	44	80
1. Awns not twisted at the base.....2		
2. Central awn coiled at the base..... <i>Aristida basiramea</i>	44	80
2. Central awn not coiled at the base.....3		
3. First glume one-third the length of the second.... <i>Aristida longiseta</i>	44	80
3. First glume about equaling the second.....4		31

Figure 44.

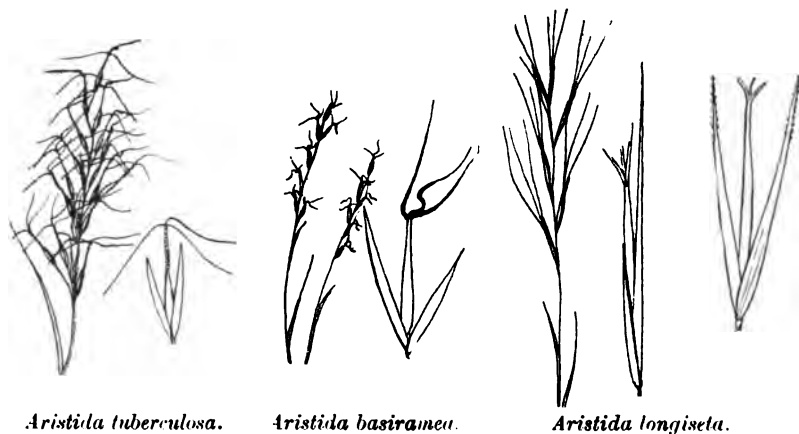


	FIG.	PAGE
4. First glume 5-7 nerved..... <i>Aristida oligantha</i>	45	80
4. First glume 1-3 nerved.....5		
5. Middle awn horizontal; much longer than the lateral awns <i>Aristida gracilis</i>	45	80
5. Middle awn not horizontal; as long as the lateral awns <i>Aristida purpurea</i>	45	80

Figure 45.



Aristida oligantha.



Aristida gracilis.

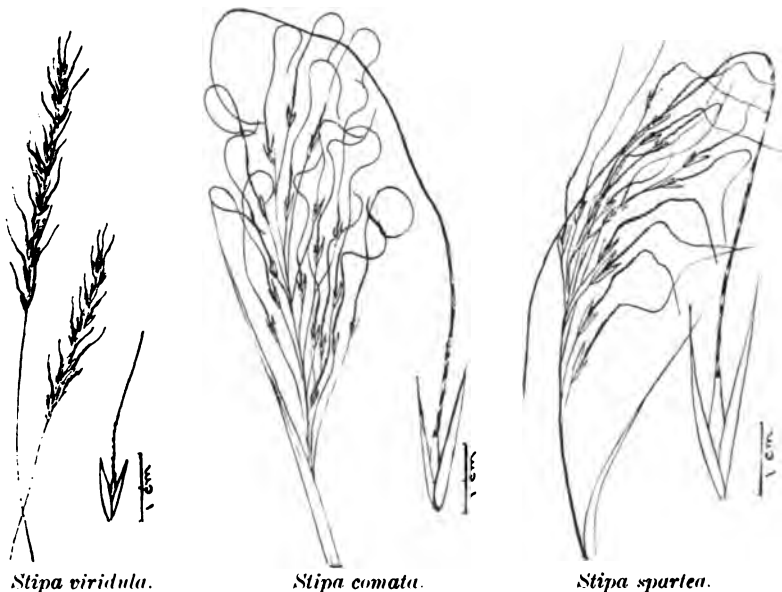


Aristida purpurea.

STIPA.

		FIG.	PAGE
1. Glumes 1.5 cm. long or less.....	<i>Stipa viridula</i>	46	94
1. Glumes 2.0 cm. long or more.....	2		
2. Lemma 8-12 mm. long; awn slender and curled	<i>Stipa comata</i>	46	93
2. Lemma 20-25 mm. long.....	<i>Stipa spartea</i>	46	94

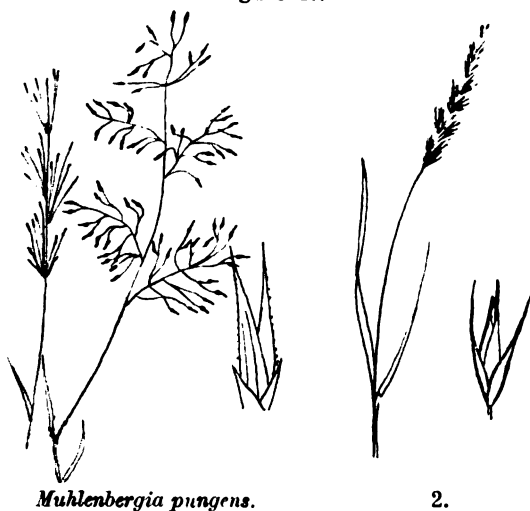
Figure 46.



MUHLENBERGIA.

	FIG.	PAGE
1. Panicle open <i>Muhlenbergia pungens</i>	47	89
1. Panicle contracted 2	47	

Figure 47.



2. Lemma awn-pointed	3	48	34
2. Lemma long awned.....	4	48	34

Figure 48.

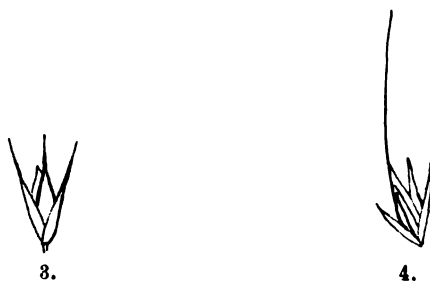
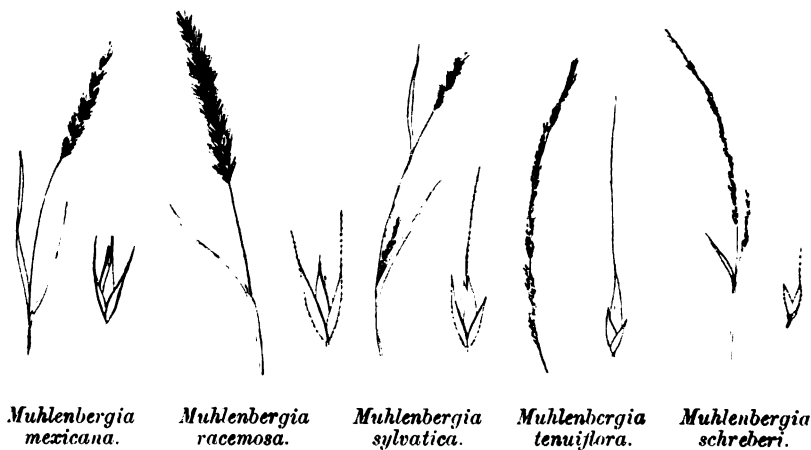


	FIG.	PAGE
1. Glumes nearly equal in length to the lemma.....		
..... <i>Muhlenbergia mexicana</i>	49	88
3. Glumes longer than the lemma and awned.....		
..... <i>Muhlenbergia racemosa</i>	49	89
4. Glumes equal to the lemma.....		
..... <i>Muhlenbergia sylvatica</i>	49	89
4. Glumes one-half as long as the lemma.....		
..... <i>Muhlenbergia tenuiflora</i>	49	89
4. Glumes less than one-fourth as long as the lemma		
..... <i>Muhlenbergia schreberi</i>	49	89

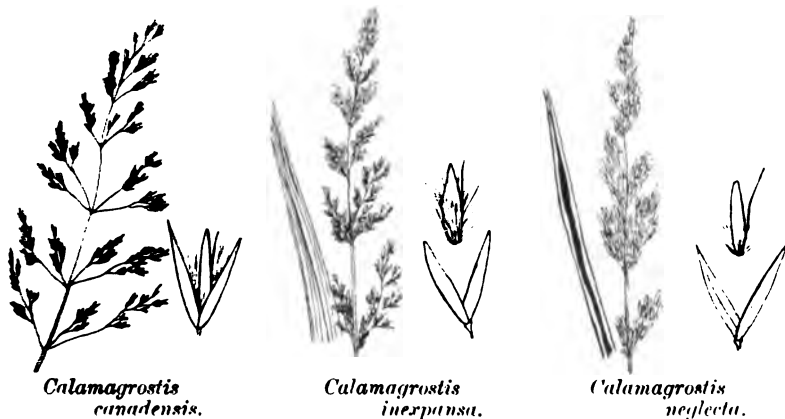
Figure 49.



CALAMAGROSTIS.

	FIG.	PAGE
1. Panicle open, branches spreading.....		
..... <i>Calamagrostis canadensis</i>	50	83
1. Panicle narrow or contracted.....2		
2. Leaves flat; basal hairs about equaling the flower	<i>Calamagrostis inexpansa</i>	50 83
2. Leaves rolled together in drying; basal hairs half as long as the flower.....		
..... <i>Calamagrostis neglecta</i>	50	83

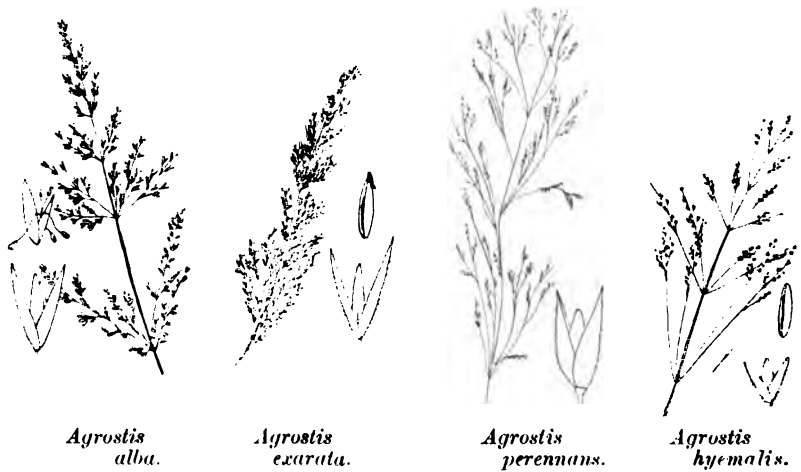
Figure 50.



AGROSTIS.

	FIG.	PAGE
1. Palea conspicuous..... <i>Agrostis alba</i>	51	78
1. Palea very small or wanting.....2		
2. Panicle narrow..... <i>Agrostis exarata</i>	51	78
2. Panicle diffusely spreading.....3		
3. Culms weak, usually spreading on the ground.....		
..... <i>Agrostis perennans</i>	51	78
3. Culms and leaves erect..... <i>Agrostis hyemalis</i>	51	78

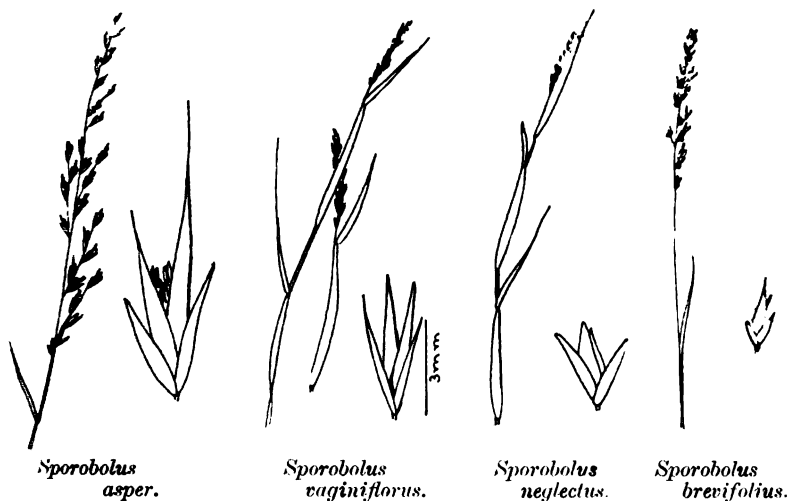
Figure 51.



SPOROBOLUS.

	FIG.	PAGE
1. Panicle contracted	2	
1. Panicle open	5	
2. Spikelets 3-5 mm. or more in length.....	3	
2. Spikelets 3 mm. or less in length.....	4	
3. Palea long awn-pointed.....	<i>Sporobolus asper</i>	52 93
3. Palea not long awn-pointed; panicles conspicuous	<i>Sporobolus vaginiflorus</i>	52 93
4. Sheaths inflated and including panicles.....	<i>Sporobolus neglectus</i>	52 93
4. Sheaths not inflated.....	<i>Sporobolus brevifolius</i>	52 93

Figure 52.



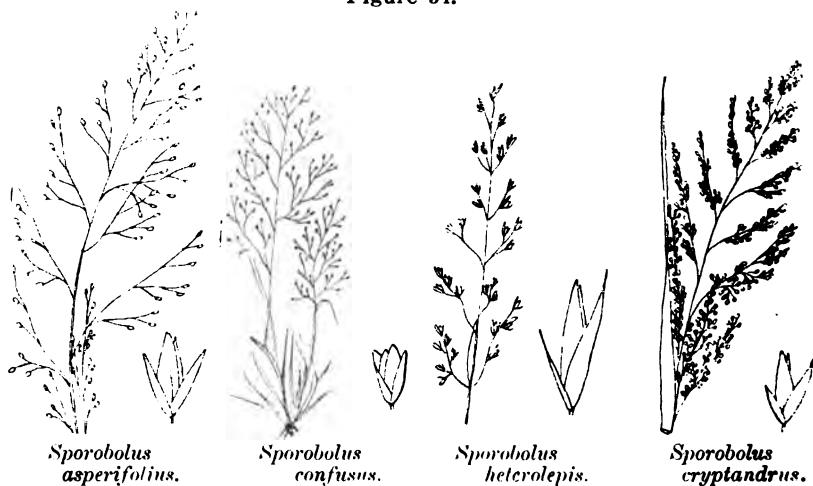
5. First glume about equaling the second.....	6	53	38
5. First glume one-half as long as the second.....	7	53	38

Figure 53.



	FIG.	PAGE
6. Perennial with a long rhizome.....		
..... <i>Sporobolus asperifolius</i>	54	93
6. Annual		
..... <i>Sporobolus confusus</i>	54	93
7. First glume awn-pointed....		
..... <i>Sporobolus heterolepis</i>	54	93
7. First glume not awn-pointed.....		
..... <i>Sporobolus cryptandrus</i>	54	93

Figure 54.



AVENEAE.

	FIG.	PAGE
1. Awn of second glume hook-like..... <i>Holcus lanatus</i>	55	87
1. Awn of second flower not hook-like.....2	55	40

Figure 55.

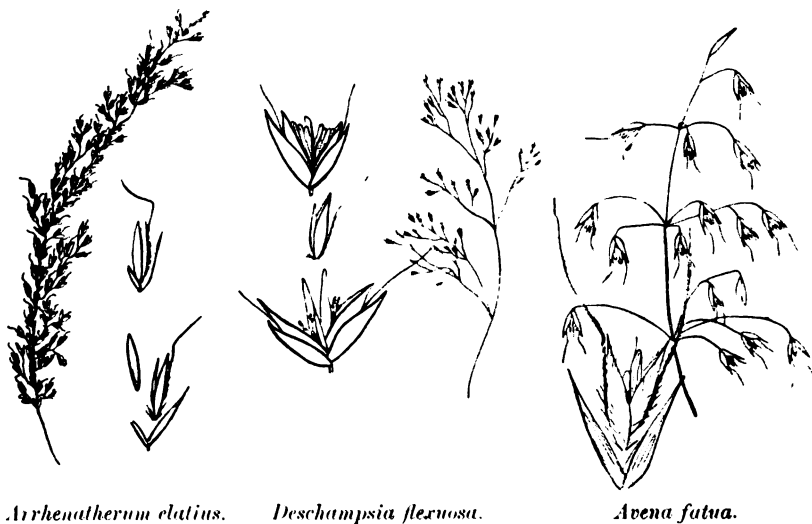


Holcus lanatus.



	FIG.	PAGE
2. Upper flower of spikelet perfect; the lower staminate	<i>Arrhenatherum elatius</i>	56 80
2. Flowers all perfect, or the upper ones staminate	3	
3. Spikelets less than 12 mm. long	<i>Deschampsia flexuosa</i>	56 84
3. Spikelets more than 12 mm. long	<i>Avena fatua</i>	56 80

Figure 56.



CHLORIDEAE.

	FIG.	PAGE
1. Spikelets, with staminate flowers, in conspicuous spikes; pistillate flowers partially included in broad sheaths..... <i>Buchloe dactyloides</i>	57	82
1. Spikelets with perfect flowers.....2		
2. Spikes digitate	3	57 42
2. Spikes racemose	4	57 42

Figure 57.

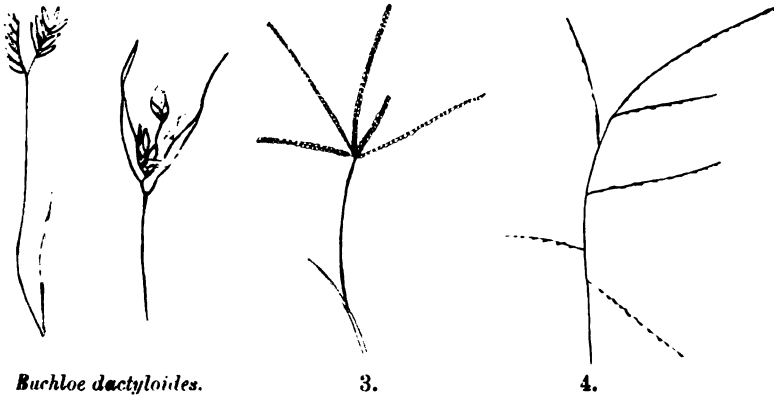
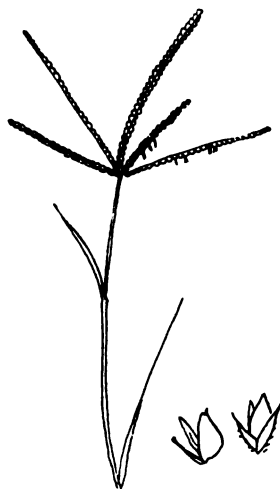
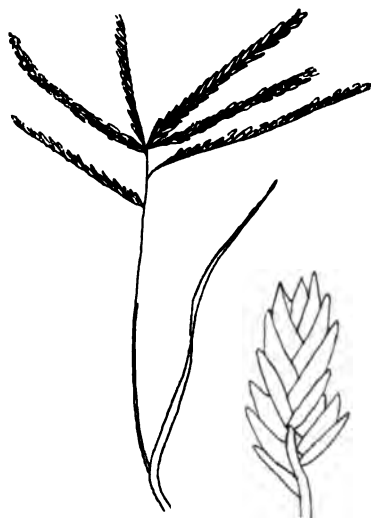


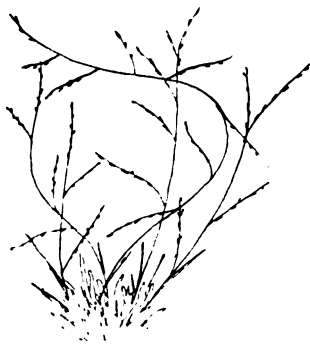
		FIG.	PAGE
3. Spikelet 1-flowered.....	<i>Cynodon dactylon</i>	58	84
3. Spikelet 3-6-flowered.....	<i>Eleusine indica</i>	58	85

Figure 58.

*Cynodon dactylon.**Eleusine indica.*

4. Spikelets not crowded.....			
.....	<i>Schedonnardus paniculatus</i>	59	92
4. Spikelets crowded	5	59	43

Figure 59.

*Schedonnardus paniculatus.*

5.

	FIG.	PAGE
5. Rachilla extending beyond the flower and bearing awns 6	60	43
5. Rachilla not extending beyond the flower.....8	60	44

Figure 60.



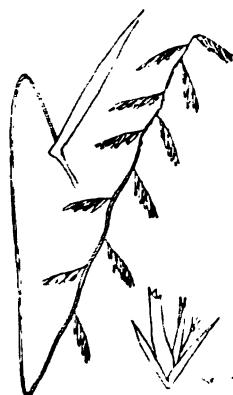
6.



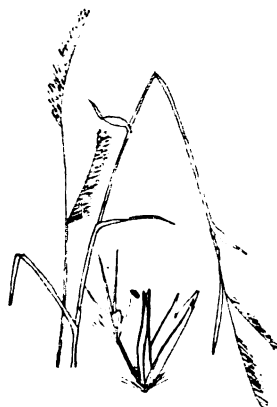
8.

6. Spikes numerous.....	<i>Bouteloua curtipendula</i>	61	80
6. Spikes one to four.....7			
7. Rachilla with tuft of long hairs at the base.....			
.....	<i>Bouteloua oligostachya</i>	61	81
7. Rachilla without tuft of long hairs at the base....			
.....	<i>Bouteloua hirsuta</i>	61	81

Figure 61.



Bouteloua curtipendula.



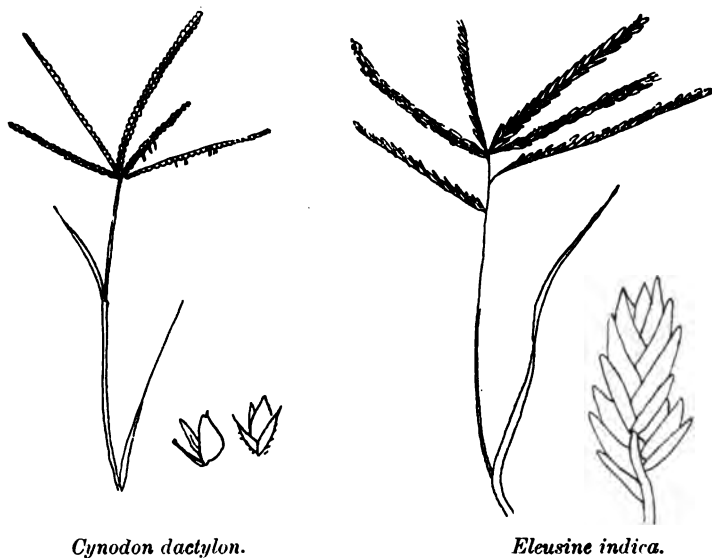
Bouteloua oligostachya.



Bouteloua hirsuta.

		FIG.	PAGE
3. Spikelet 1-flowered.....	<i>Cynodon dactylon</i>	58	84
3. Spikelet 3-6-flowered.....	<i>Eleusine indica</i>	58	85

Figure 58.



4. Spikelets not crowded.....			
.....	<i>Schedonnardus paniculatus</i>	59	92
4. Spikelets crowded	5	59	43

Figure 59.

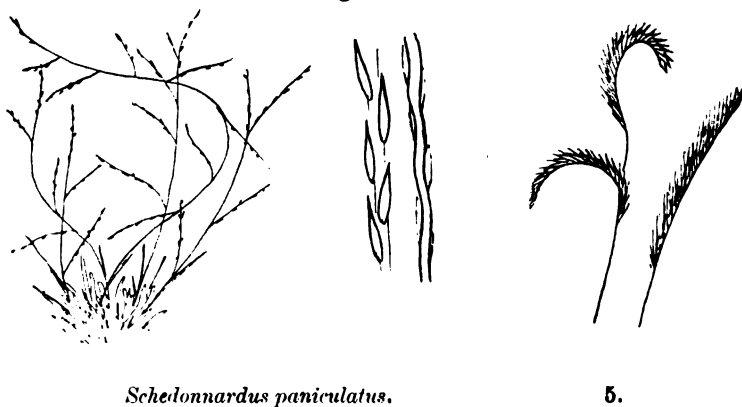


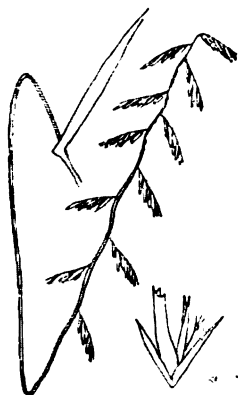
	FIG.	PAGE
5. Rachilla extending beyond the flower and bearing awns	6	43
5. Rachilla not extending beyond the flower.....	8	44

Figure 60.



6. Spikes numerous.....	<i>Bouteloua curtipendula</i>	61	80
6. Spikes one to four.....	7		
7. Rachilla with tuft of long hairs at the base.....	<i>Bouteloua oligostachya</i>	61	81
7. Rachilla without tuft of long hairs at the base....	<i>Bouteloua hirsuta</i>	61	81

Figure 61.



Bouteloua curtipendula.



Bouteloua oligostachya.



Bouteloua hirsuta.

	FIG.	PAGE
8. Rachilla not extending beyond the upper spikelet	<i>Beckmannia erucaeformis</i>	62 80
8. Rachilla extending beyond the upper spikelet	9	
9. Spikes more than 5 cm. long, <i>Spartina michauxiana</i>	62	93
9. Spikes less than 5 cm. long.....	<i>Spartina gracilis</i>	62 92

Figure 62.



FESTUCEAE.

1. Plants prostrate; spikelets in terminal clusters surrounded by stiff leaves....	<i>Munroa squarrosa</i>	63 80
1. Plants erect; spikelets in loose or contracted panicles	2	63 45

Figure 63.

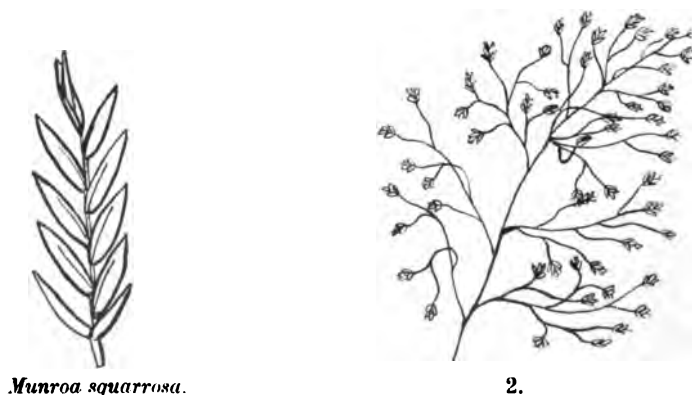


	FIG.	PAGE
2. Rachilla clothed with long silky hairs exceeding the florets..... <i>Phragmites communis</i>	64	90
2. Rachilla naked, or with short hairs.....3	64	

Figure 64.



Phragmites communis.



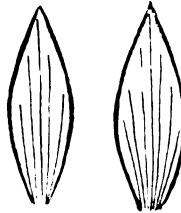
3.

3. Lemma 1-3-nerved or nerveless.....4	65	46
3. Lemma 5-many-nerved	10	65 49

Figure 65.



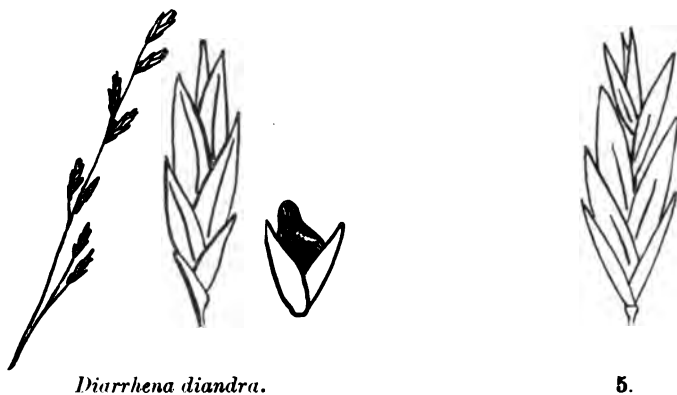
4.



10.

	FIG.	PAGE
4. Lemma hard; seed beaked and protruding beyond the glumes and lemma.....		
..... <i>Diarrhena diandra</i>	66	84
4. Lemma soft; seed not beaked nor protruding..	5	66

Figure 66.



5. Lateral nerves of the lemma hairy.....		
..... <i>Triplasis purpurea</i>	67	94
5. Lateral nerves of the lemma smooth.....	6	67
		47

Figure 67.

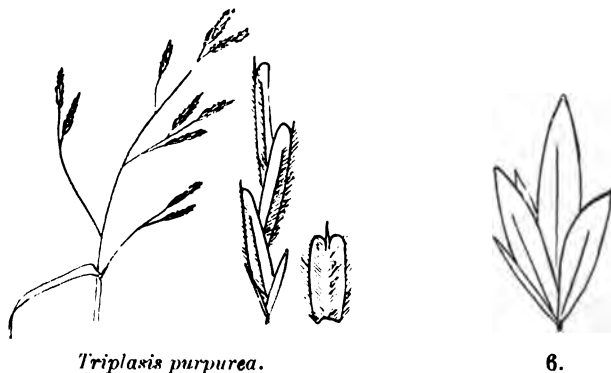
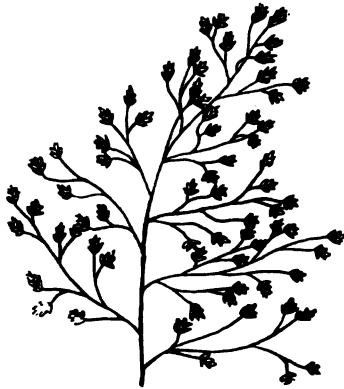


	FIG.	PAGE
6. Lemma hairy at the base.... <i>Redfieldia flexuosa</i>	68	91
6. Lemma not hairy at the base.....7	68	

Figure 68.



Redfieldia flexuosa.



7.

7. Second glume very unlike the first.... <i>Sphenopholis</i>	69	52
7. Second glume like the first.....8	69	48

Figure 69.



Sphenopholis.



8.

	FIG.	PAGE
8. Panicle dense and spike-like, <i>Koeleria cristata</i>	70	87
8. Panicle open 9		
9. Spikelets 2-flowered; aquatic... <i>Catabrosa aquatica</i>	70	83
9. Spikelets 3-many-flowered; terrestrial... <i>Eragrostis</i>	70	52

Figure 70.

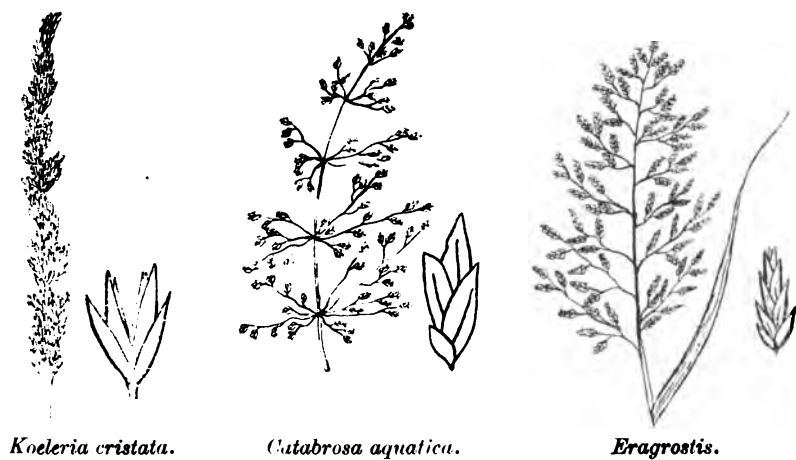


	FIG.	PAGE
10. Spikelets with upper flowers sterile and folded about each other	<i>Melica nitens</i>	71 88
10. Spikelets with the upper flowers perfect, narrow, or abortive		11 71

Figure 71.



Melica nitens.



11.

11. Lemma compressed and keeled.....	12	72	50
11. Lemma rounded on the back.....	14	72	50

Figure 72.



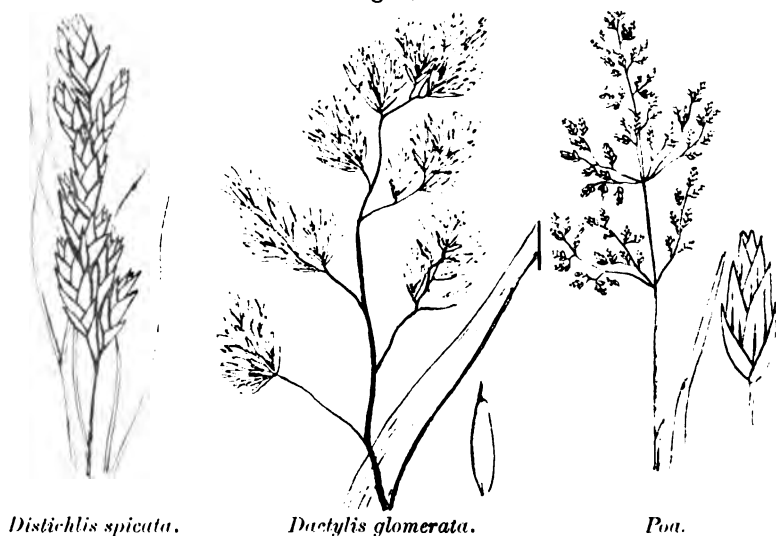
12.



14.

		FIG.	PAGE
12. Panicle contracted.....	<i>Distichlis spicata</i>	73	84
12. Panicle open	13		
13. Lemma awned or awn-pointed..	<i>Dactylis glomerata</i>	73	84
13. Lemma awnless	<i>Poa</i>	73	91

Figure 73.

*Distichlis spicata.**Dactylis glomerata.**Poa.*

14. Lemma with a basal tuft of hairs; aquatic..		
.....	<i>Scolochloa festuacea</i>	17 92
14. Lemma naked at the base.....	15	74 51

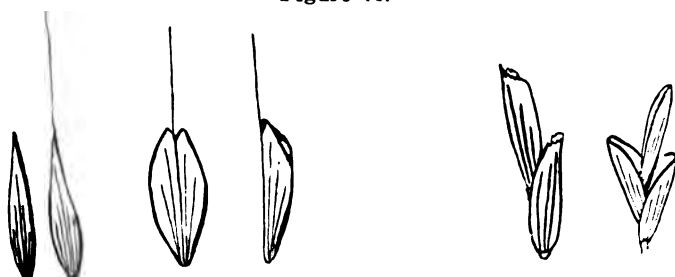
Figure 74.

*Scolochloa festuacea.*

15.

	FIG.	PAGE
15. Apex of lemma acute, entire, pointed, or awned... .. <i>Festuca</i>	75	58
15. Apex of lemma 2-toothed, awn below the apex; or awnless and broadly rounded or obtuse at the tip	16	75
16. Style attached below the apex of the ovary.. .. <i>Bromus</i>		60
16. Style attached to the apex of the ovary....	17	

Figure 75.



Festuca.

16.

17. Lemma obscurely 5-nerved....	<i>Puccinellia airoides</i>	76	91
17. Lemma prominently 6-7-nerved.....	18		
18. Second glume 1 mm. long....	<i>Glyceria nervata</i>	76	87
18. Second glume 2.0-3.5 mm. long.....			
.....	<i>Glyceria grandis</i>	76	87

Figure 76.



Puccinellia airoides.

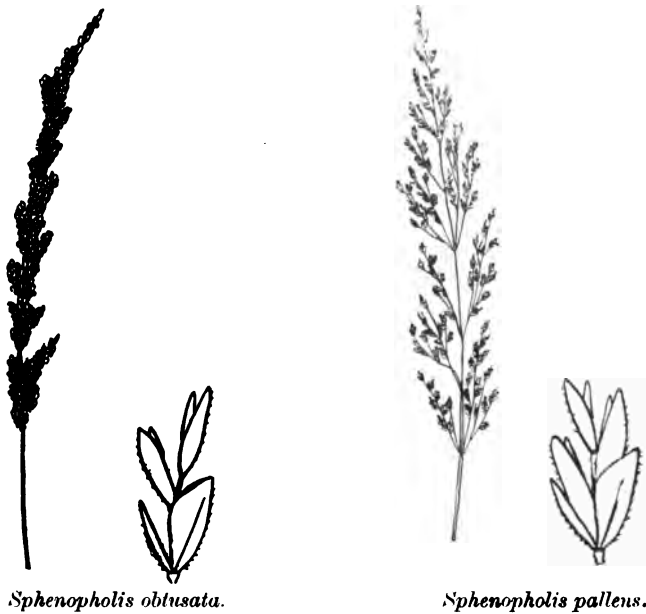
Glyceria nervata.

Glyceria grandis.

SPHENOPHOLIS.

		FIG.	PAGE
1. Panicle dense.....	<i>Sphenopholis obtusata</i>	77	93
1. Panicle longer.....	<i>Sphenopholis pallens</i>	77	93

Figure 77.



ERAGROSTIS.

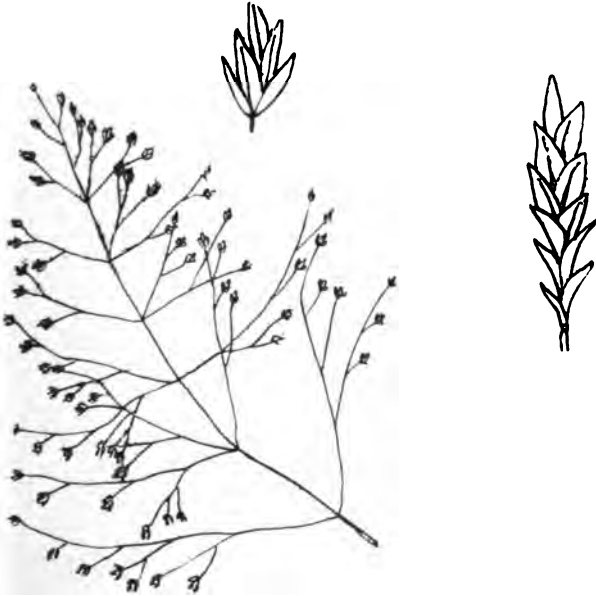
1. Lemma with obscure lateral nerves.....	2	78	53
1. Lemma with prominent to conspicuous nerves....	4	78	54

Figure 78.



	FIG.	PAGE
2. Spikelets 2-5-flowered..... <i>Eragrostis capillaris</i>	79	86
2. Spikelets more than 5-flowered.....3	79	54

Figure 79.



Eragrostis capillaris.

3.

	FIG.	PAGE
3. Spikelets 6-20-flowered; panicle 15-30 cm. long....		
..... <i>Eragrostis pilosa</i>	80	86
3. Spikelets 10-40-flowered; panicle 3-6 cm. long.....		
..... <i>Eragrostis hypnoides</i>	80	86

Figure 80.

*Eragrostis pilosa.**Eragrostis hypnoides.*

4. Spikelets less than 3 mm. wide.....	5	
4. Spikelets 3 mm. or more wide.....	7	56
5. Sheaths overlapping.....	<i>Eragrostis pectinacea</i>	81 86
5. Sheaths shorter than the internodes.....	6	81 55

Figure 81.

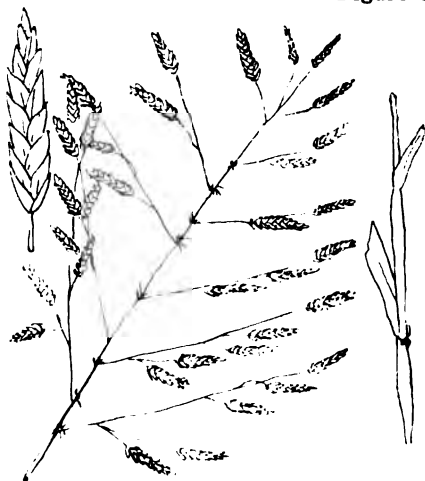
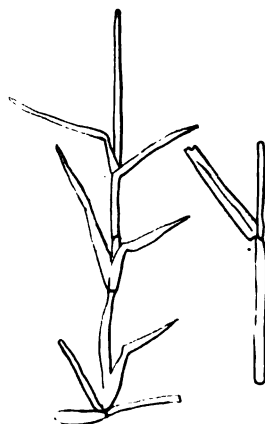
*Eragrostis pectinacea.*

	FIG.	PAGE
6. Panicle narrow, 3-6 cm. long; spikelets 10-40-flowered	<i>Eragrostis hypnoides</i>	82 86
6. Panicle 6-24 cm. long; spikelets 3-15-flowered..	<i>Eragrostis pilosa</i>	82 86

Figure 82.

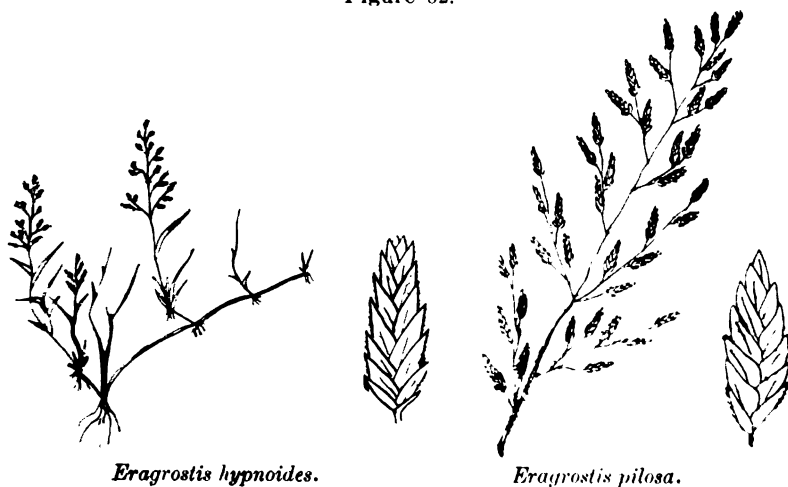
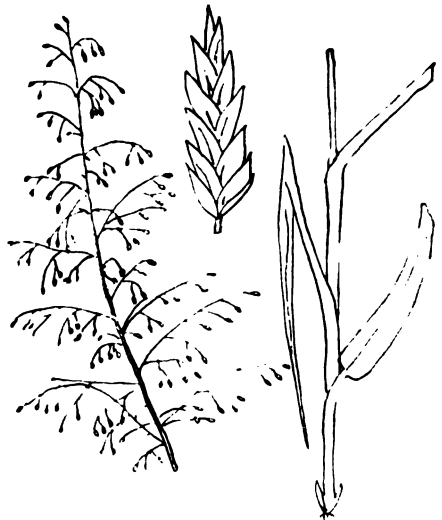


		FIG.	PAGE
7. Sheaths shorter than the internodes; panicle 5-15 cm. long.....	<i>Eragrostis megastachya</i>	83	86
7. Sheaths overlapping; panicle 22-67 cm. long.....	<i>Eragrostis trichodes</i>	83	86

Figure 83.

*Eragrostis megastachya.**Eragrostis trichodes.*

POA.

	FIG.	PAGE
1. Lemma without basal hairs..... <i>Poa annua</i>	85	91
1. Lemma with basal hairs.....2	85	

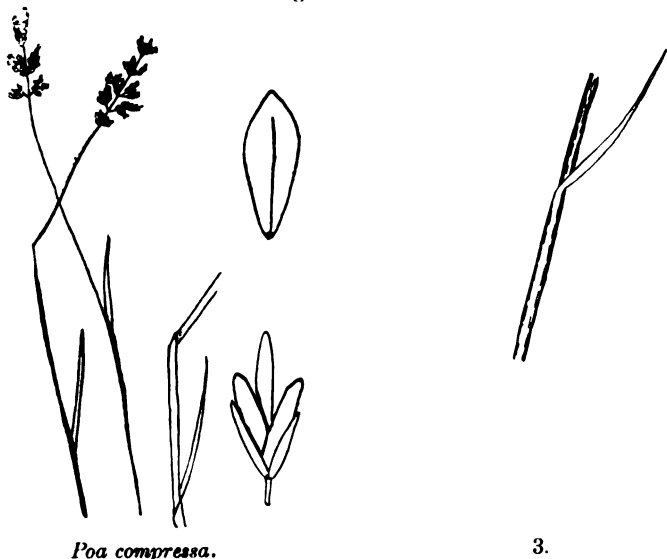
Figure 85.



Poa annua.

2. Culms greatly flattened; flowers usually broader above than below the middle.....		
..... <i>Poa compressa</i>	86	91
2. Culms rounded, not greatly flattened.....3	86	58

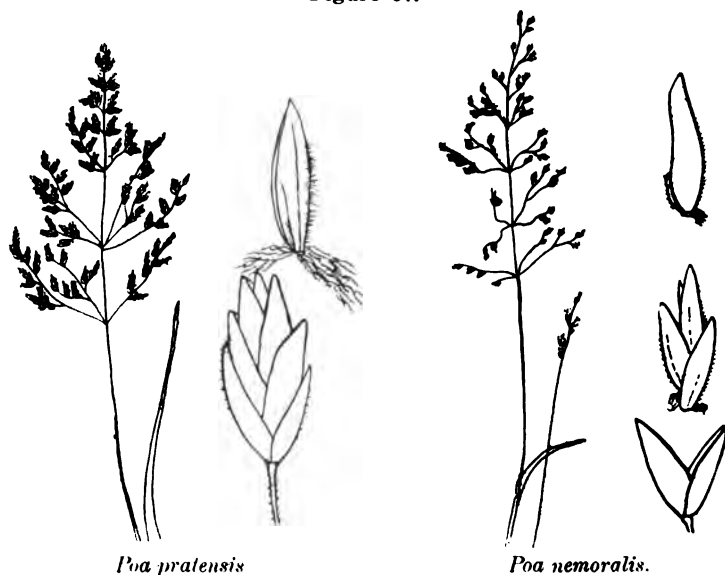
Figure 86.



Poa compressa.

		FIG.	PAGE
3. Intermediate nerves distinct.....	<i>Poa pratensis</i>	87	91
3. Intermediate nerves not distinct....	<i>Poa nemoralis</i>	87	91

Figure 87.



FESTUCA.

1. Leaves 2 mm. wide or less, involute when dry.....	2	88	59
1. Leaves 4 mm. wide or more, flat when dry.....	4	88	60

Figure 88.



	FIG.	PAGE
2. Spikelets 5-13-flowered <i>Festuca octoflora</i>	89	87
2. Spikelets 3-6-flowered 3		
3. Panicle close, contracted, expanding while in bloom <i>Festuca ovina</i>	89	87
3. Panicle open and spreading <i>Festuca altaica</i>	89	86

Figure 89.

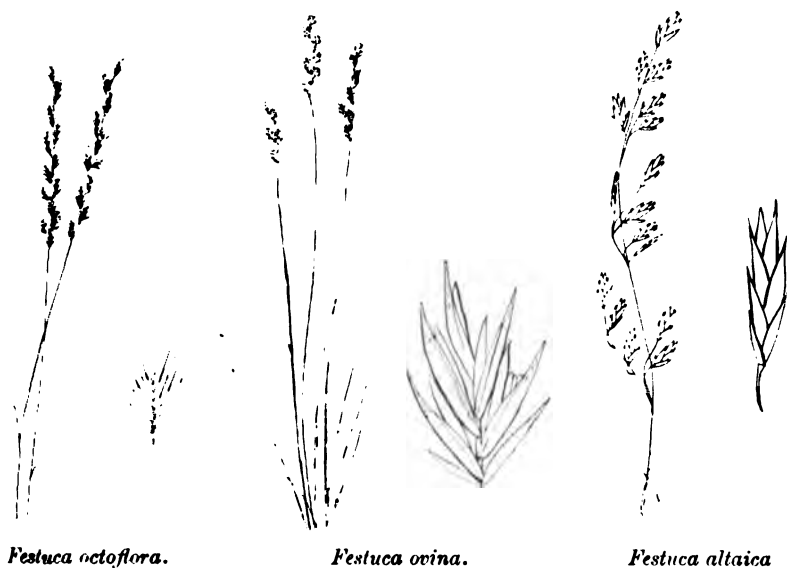
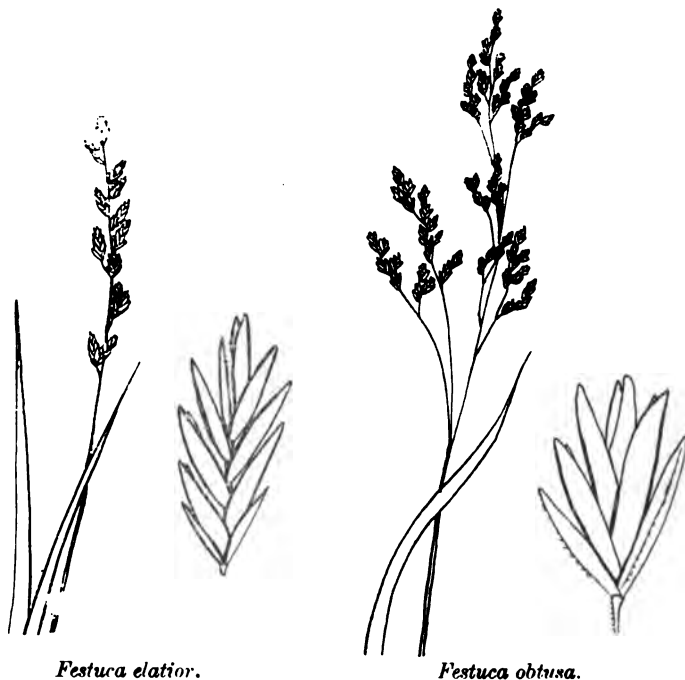


		FIG.	PAGE
4. Spikelets 5-10-flowered.....	<i>Festuca elatior</i>	90	86
4. Spikelets 3-5-flowered.....	<i>Festuca obtusa</i>	90	87

Figure 90.



BROMUS.

1. First glume 1-nerved.....	2	91	61
1. First glume 3-nerved	5	91	63

Figure 91.



	FIG.	PAGE
2. Awn shorter than the lemma or wanting; tall perennials	92	62
2. Awn longer than the lemma; low annuals..... <i>Bromus tectorum</i>	92	82

Figure 92.



3.



Bromus tectorum.

	FIG.	PAGE
3. Lemma with awn 1 mm. long, awn-pointed, or awnless <i>Bromus inermis</i>	93	81
3. Lemma with awn 6 mm. long or more. 4		
4. Culms stout; branches of the panicle more or less spreading or drooping. . <i>Bromus ciliatus</i>	93	81
4. Culms slender; branches of the panicle erect. <i>Bromus erectus</i>	93	81

Figure 93.

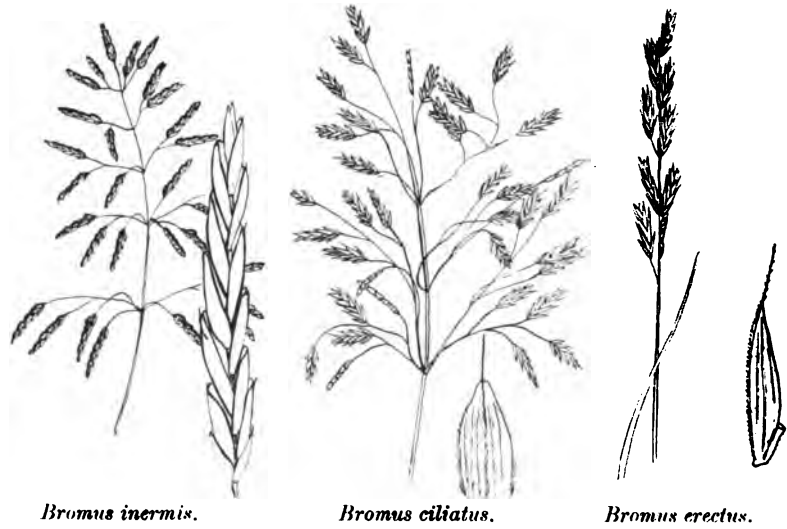


	FIG.	PAGE
5. Lemma awned	6	94
5. Lemma awnless or with short awn; nearly as long as broad.....	<i>Bromus brizaeformis</i>	94 81

Figure 94.



6. Lemma hairy	7	95	64
6. Lemma smooth	9	95	65

Figure 95.



	FIG.	PAGE
7. Lemma covered with short appressed hairs.....		
..... <i>Bromus hordeaceus</i>	96	81
7. Lemma covered with long silky hairs.....	8	
8. Second glume 3-nerved..... <i>Bromus porteri</i>	96	82
8. Second glume 5-7-nerved..... <i>Bromus kalmii</i>	96	82

Figure 96.

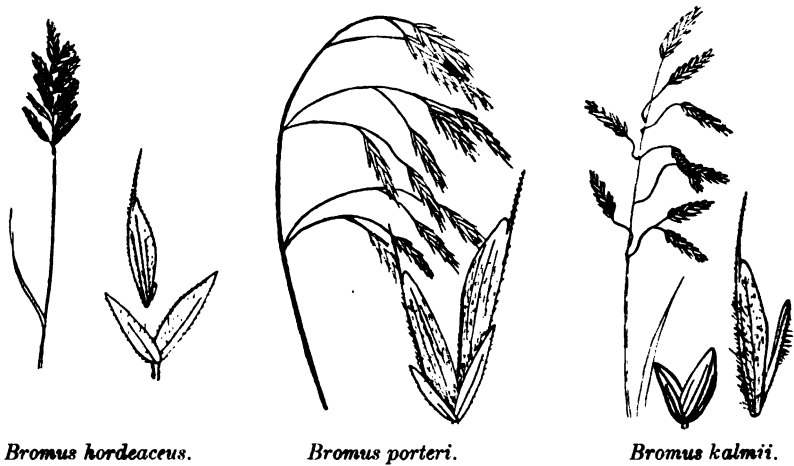


	FIG.	PAGE
9. Awns straight 10	97	66
9. Awns strongly bent near the base.....		
..... <i>Bromus squarrosus</i>	97	82

Figure 97.



10.

Bromus squarrosus.

		FIG.	PAGE
10. Sheaths smooth	<i>Bromus secalinus</i>	98	82
10. Sheaths hairy.....	<i>Bromus racemosus</i>	98	82

Figure 98.

*Bromus secalinus.**Bromus racemosus.***HORDEAE.**

1. Spikelets solitary in the notches of the zigzag rachis	2	99	67
1. Spikelets 2-6 in each notch of the zigzag rachis....	3	99	68

Figure 99.



2.

3.

	FIG.	PAGE
2. Spikelet with its edge to the rachis..... <i>Lolium</i>	100	70
2. Spikelet with its side to the rachis.. <i>Agropyron</i>	100	71

Figure 100.



Agropyron.



Lolium.

	FIG.	PAGE
3. Spikelet 1-flowered, with two aborted spikelets....		
..... <i>Hordeum</i>	101	76
3. Spikelet 2-many flowered	4	101

Figure 101.



Hordeum.



4.

4. Glumes minute or none.....	<i>Hystrix patula</i>	102	87
4. Glumes usually equaling the lemma.....	5	102	69

Figure 102.



Hystrix patula.



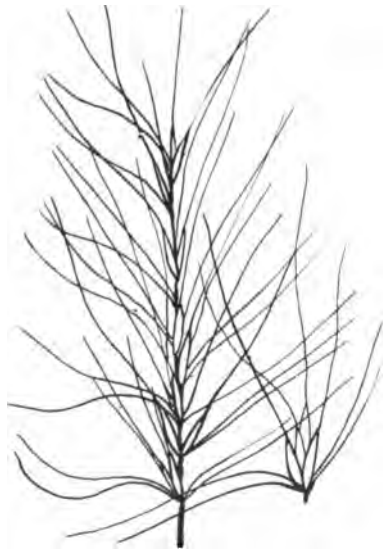
5.

	FIG.	PAGE
5. Rachis continuous	<i>Elymus</i> 103	73
5. Rachis articulated and fragile.....	<i>Sitanion hystrix</i> 103	92

Figure 103.



Elymus.

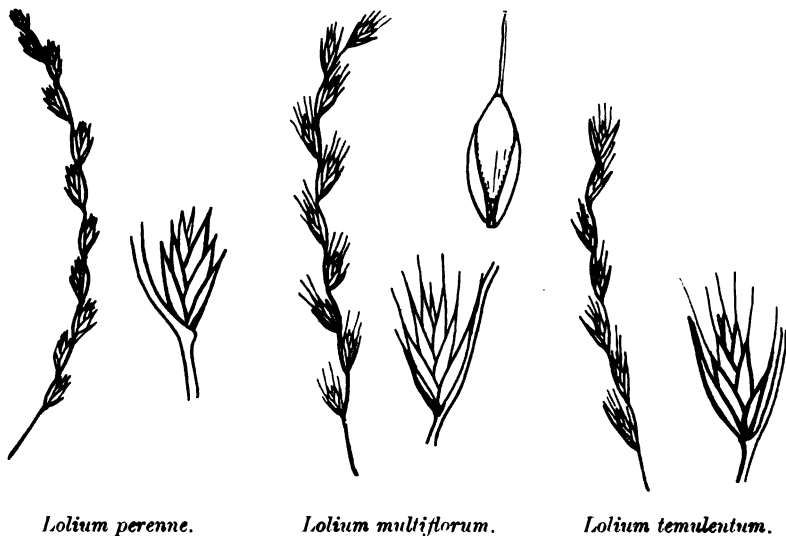


Sitanion hystrix.

LOLIUM.

	FIG.	PAGE
1. Lemma awn-pointed or awnless..... <i>Lolium perenne</i>	104	89
1. Lemma long-awned	2	
2. Glume shorter than the lemma.....		
..... <i>Lolium multiflorum</i>	104	89
2. Glume as long as or exceeding the lemma....		
..... <i>Lolium temulentum</i>	104	89

Figure 104.



AGROPYRON.

	FIG.	PAGE
1. With rhizome	2	105
1. Without rhizome	3	105
		72

Figure 105.



2. Spikelet 3-7-flowered	<i>Agropyron repens</i>	106	77
2. Spikelet 7-13-flowered	<i>Agropyron smithii</i>	106	78

Figure 106.

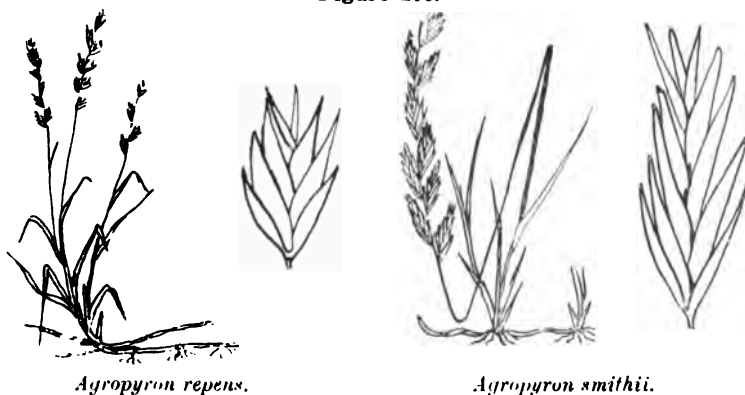
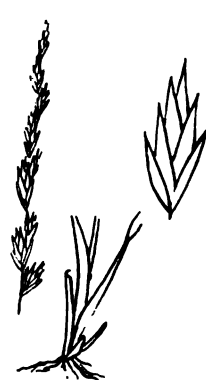


	FIG.	PAGE
3. Lemma long-awned..... <i>Agropyron caninum</i>	107	77
3. Lemma short-awned, or awnless.....4		
4. Spikes 8-20 cm. long; green or straw colored <i>Agropyron tenerum</i>	107	78
4. Spikes 3-10 cm. long; purplish..... <i>Agropyron biflorum</i>	107	77

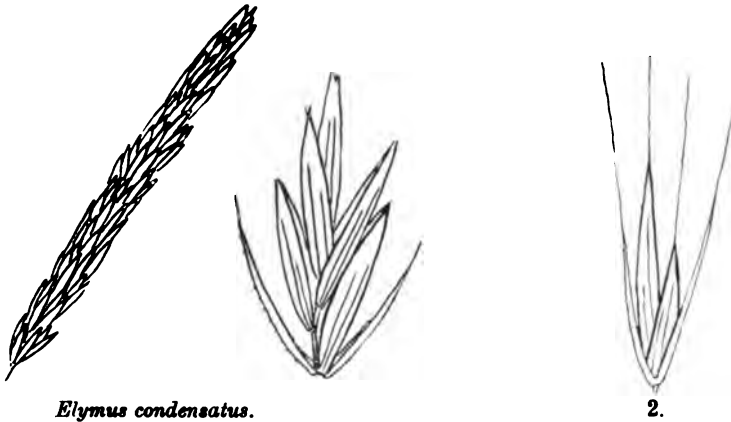
Figure 107.

*Agropyron caninum.**Agropyron tenerum.**Agropyron biflorum.*

ELYMUS.

	FIG.	PAGE
1. Lemma awnless or awn-pointed.....		
..... <i>Elymus condensatus</i>	108	85
1. Lemma conspicuously awned.....	2	108

Figure 108.



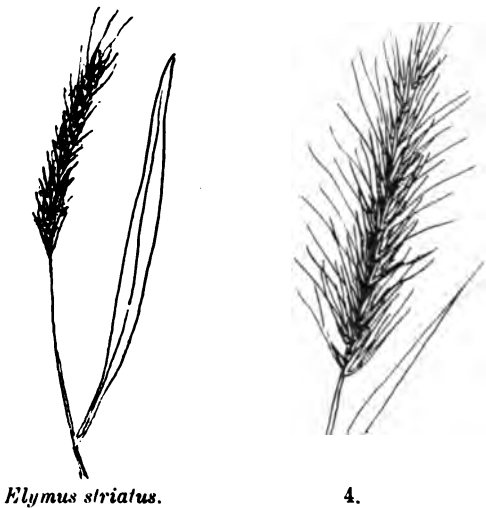
2. Spikelets divergent from the rachilla of the broad spike	3	109	74
2. Spikelets appressed to the rachilla of the narrow spike	6	109	75

Figure 109.



	FIG.	PAGE
3. Spike slender	<i>Elymus striatus</i> 110	86
3. Spike stout	4 110	

Figure 110.



4. Lemma smooth	<i>Elymus virginicus</i> 111	86
4. Lemma rough or hairy	5 111	75

Figure 111.

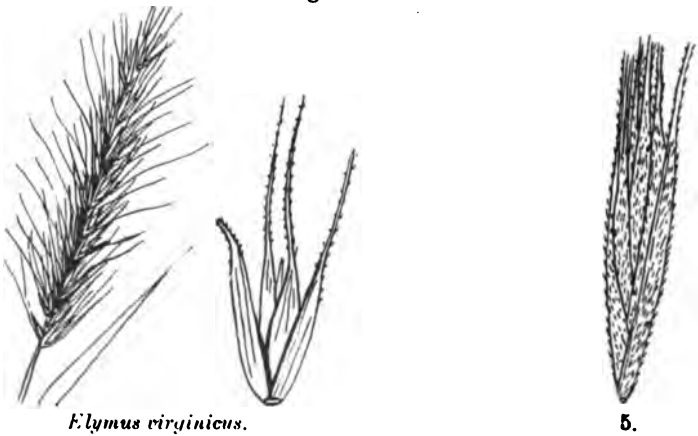
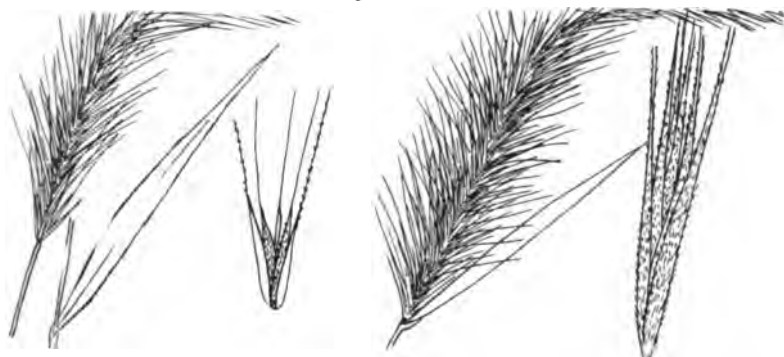


	FIG.	PAGE
5. Spike loosely flowered; long pedicelled.....		
..... <i>Elymus canadensis</i>	112	85
5. Spike densely flowered; included at the base.....		
..... <i>Elymus robustus</i>	112	86

Figure 112.



Elymus canadensis.

Elymus robustus.

6. Spikelet 3-6-flowered.....	<i>Elymus glaucus</i>	113	85
6. Spikelet 1-3-flowered.....	<i>Elymus macounii</i>	113	85

Figure 113.



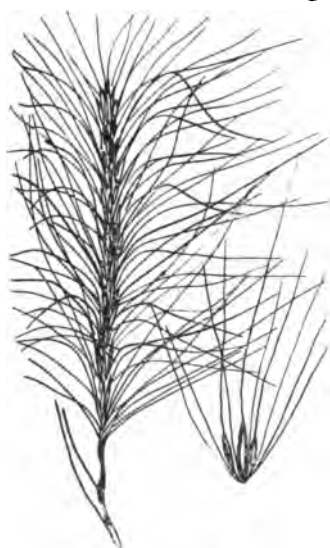
Elymus glaucus

Elymus macounii.

HORDEUM.

	FIG.	PAGE
1. Spikes bushy; with spreading awns.....		
..... <i>Hordeum jubatum</i>	114	87
1. Spikes narrow; with nearly erect awns.....		
..... <i>Hordeum pusillum</i>	114	87

Figure 114.

*Hordeum jubatum.**Hordeum pusillum.*

NOTES ON ECONOMIC GRASSES.

No grass can be grown under cultivation on any large scale unless it is possible to secure its seeds in sufficient quantity and at a reasonable price. The failure of many otherwise very desirable species to seed freely under cultivation makes their use quite impossible.

The use of grasses for specific purposes depends upon various other characters, only one of which is here mentioned. Rhizomes of many perennial grasses are continued by the formation of shoots from the lower nodes of the flowering shoots. The method by which these shoots are formed determines whether the grass will be a "bunch" grass or a sod or "turf" grass. The buds mentioned develop within the sheath and if they continue their growth enclosed by the sheath they are called intra-vaginal. Such grasses are apt to form bunches or tussocks. On the other hand, if these buds early break thru the sheath, then extra-vaginal shoots result and these spread the grass over a considerable area by means of the resulting stolons. This type of grass will form a more or less compact turf or sod. Moreover, bunch grasses would be of little value as sand binders in comparison with grasses of the latter type.

The following notes have been compiled to serve as an introduction to further study and experimentation with our native grasses. The Department of Agricultural Botany desires to receive specimens of our native grasses and information concerning their behavior. Such specimens will furnish us more accurate data regarding the distribution of our various grasses thruout the several counties.

AGROPYRON.

1. *Agropyron biflorum*. Purple Wheat Grass. (Fig. 107.)

A slender perennial of western Nebraska.

2. *Agropyron caninum*. Awned Wheat Grass. (Fig. 107.)

An erect grass sparingly naturalized in cultivated ground and meadows. The bearded nodding heads resemble somewhat heads of wheat. Unlike Couch Grass this species has no rootstocks. It may readily be propagated by the seeds, which are easily gathered.

3. *Agropyron repens*. Couch Grass. (Fig. 106.)

A stout perennial grass which forms a dense sod by means of its extensive system of rhizomes. It is a valuable hay grass, but, like Western Wheat Grass, it soon

"binds itself out" and the sod must again be broken to restore the yield. It should prove to be a valuable sand-binding grass on railroad embankments and other places subject to blow-out. It is ordinarily considered a noxious weed, the eradication of which is very difficult.

4. *Agropyron smithii*. Western Wheat Grass. (Fig. 106.)

In the western part of the State this is one of our most valuable grasses. It is an erect perennial resembling in many respects Couch Grass, but on account of the bluish color of its foliage often receives the name "Bluestem," a name, however, which should be reserved for species of *Andropogon*.

5. *Agropyron tenerum*. Slender Wheat Grass. (Fig. 107.)

This is a perennial bunch grass of the western prairies. The seed can ordinarily be secured on the market, and its cultivation may be expected to increase in the future. It produces a large amount of forage and ripens an abundance of seed.

AGROSTIS.

6. *Agrostis alba*. Redtop. (Fig. 51.)

This is an upright hardy perennial whose rhizomes form a rather dense sod. The existence of many forms of this species has led to much diversity of opinion as to the value of the grass under cultivation. The taller forms may be cut for hay, while the low-growing sorts are unsurpassed lawn grasses. It prefers a rather moist soil and should do best when sown with clovers or other grasses. It prefers a rather moist soil and should do best when sown with clovers or other grasses. In low ground it often drives out the native grasses.

7. *Agrostis exarata*. Northern Redtop. (Fig. 51.)

This is a variable species found in the wet places in the western part of the State. Some of the forms are to be recommended for cultivation on account of their heavy foliage and vigorous growth.

8. *Agrostis hyemalis*. Hair Grass. (Fig. 51.)

A well-known slender grass of the early summer found thruout the State. The panicle is often blown about like a tumbleweed.

9. *Agrostis perennans*. Thin Grass. (Fig. 51.)

This species is much like *Agrostis hyemalis* but flowers much later in the season. Cass County.

ALOPECURUS.

10. *Alopecurus geniculatus*. Water Foxtail. (Fig. 33, 34.)

A low slender rather procumbent perennial grass of eastern Nebraska. In that region in low pastures and meadows it provides excellent grazing. One of the forms of this grass is a good turf grass.

ANDROPOGON.

11. *Andropogon furcatus*. Big Bluestem. (Fig. 18.)

This is a very tall perennial that formerly was very abundant on the prairies thruout the State. In the western counties it still forms a very important part of the native hay and when cut early is relished by stock. Unless the moisture supply is adequate it does not seed freely, and this is a serious defect of any grass when cultivated for hay.

12. *Andropogon halepensis*. Johnson Grass. (Fig. 17.)

This is an introduced grass long grown in the South and to a limited extent in our southern counties. It develops a very extensive system of rootstocks and in the South it is nearly impossible to eradicate it when once established.

13. *Andropogon hallii*. Colorado Sand Grass. (Fig. 18.)

This is a stout erect perennial which makes a luxuriant growth in the Sand Hills where it can be recommended as a sand-binding grass. It must be cut early if to be used for hay and, tho more woody, is perhaps as valuable as the Big Bluestem.

14. *Andropogon scoparius*. Little Bluestem. (Fig. 18.)

This rather slender perennial is a common prairie grass thruout the State. It is often associated with other species of *Andropogon* and with them may constitute a large part of the native prairie hay. The stems are generally reddish in color.

ANTHOXANTHUM.

15. *Anthoxanthum odoratum*. Sweet Vernal Grass (Fig. 32.)

A perennial sweet-scented grass with slender erect tufted stems. The bitter taste of its leaves renders it somewhat unpalatable for stock tho a small amount adds a rather pleasant fragrance to hay. Its earliness gives it some value as a pasture grass.

ARISTIDA.

16. *Aristida basiramea*. Tufted Triple Awn. (Fig. 44.)
An erect, tufted, much-branched perennial common in the Sand Hill region.
17. *Aristida gracilis*. Slender Beard Grass. (Fig. 45.)
A slender tufted annual of northern Nebraska.
18. *Aristida longiseta*. Dog Town Grass. (Fig. 44.)
A slender densely tufted, wiry perennial found in dry soils in western Nebraska.
19. *Aristida oligantha*. Prairie Triple Awn. (Fig. 45.)
In poor dry soil over most of the State.
20. *Aristida purpurea*. Purple Beard Grass. (Fig. 45.)
A common perennial prairie grass thruout the State.
21. *Aristida tuberculosa*. Long-awned Poverty Grass. (Fig. 44.)
A rigid, much-branched perennial in dry sandy soil. Kearney County.

ARRHENATHERUM.

22. *Arrhenatherum elatius*. Tall Oat Grass. (Fig. 56.)
This is a tall loosely-tufted perennial which makes an early growth, thus rendering it of some value in pastures. It grows rapidly and is very drouth-resistant. It does not form a good sod and must therefore be sown with other species.

AVENA.

23. *Avena fatua*. Wild Oats. (Fig. 56.)
This is an erect glabrous annual found in waste places. It is generally regarded as a serious weed pest—particularly since its stiff twisted awns are rather troublesome to stock.

BECKMANNIA.

24. *Beckmannia erucaeformis*. Slough Grass. (Fig. 62.)
A stout, tall, erect, coarse perennial growing in tufts along river banks and irrigation ditches. When young it is readily eaten by stock. It is particularly well adapted for low irrigated alkaline soils. Common in western Nebraska.

BOUTELOUA.

25. *Bouteloua curtipendula*. Tall Grama Grass. (Fig. 61.)
A tall densely tufted perennial with tough perennial roots. The hay is readily eaten by stock, which, however,

on the range prefer the Blue Grama Grass. Its many basal leaves render it a rather valuable pasture grass in dry regions and it cures readily when cut for hay. Thruout the State.

26. *Bouteloua hirsuta*. Black Grama. (Fig. 61.)

This is one of the common tufted perennial grasses of our western Sand Hills. When abundant it forms excellent pasturage, its dense tufts and fine leaves being much relished by stock. Thruout the State, but most abundant westward.

27. *Bouteloua oligostachya*. Blue Grama. (Fig. 61.)

This is the commonest and most valuable species of Grama Grass on the Great Plains. It is a slender, erect, tufted perennial with strong rootstocks and numerous basal leaves. No other grass withstands the tramping of stock as does this, and it is thus unsurpassed for grazing purposes. The leaves are short and crowded at the base of the short stem producing dense cushion-like masses pressed close to the ground. It is often improperly called Buffalo grass. It is very drouth-resistant and very common thruout the State.

BRACHYELYTRUM.

28. *Brachyelytrum erectum*. Bearded Short Husk. (Fig. 36.)

A slender perennial with unbranched stems in open wooded regions.

BROMUS.

29. *Bromus brizaeformis*. (Fig. 94.)

A slender, erect, tufted annual with nodding panicles of very large spikelets, introduced from Europe.

30. *Bromus ciliatus*. Swamp Chess. (Fig. 93.)

On good soils in wooded parts or shady pastures, it should make a vigorous early growth. Common thruout the State.

31. *Bromus erectus*. (Fig. 93.)

Introduced from Europe. Valley County.

32. *Bromus hordeaceus*. Soft Chess. (Fig. 96.)

An erect or ascending annual or biennial found in fields and waste places.

33. *Bromus inermis*. Awnless Brome Grass. (Fig. 93.)

This is an erect vigorous, hardy perennial with strong creeping rootstocks enabling it to form a thick and firm sod. It is a native of Europe introduced and widely cul-

tivated in many parts of the State for hay. The strong perennial character of this grass and its great drouth-resisting power are qualities which recommend it for general cultivation particularly in semiarid regions. This drouth-resistance was proved for this grass as much as 30 years ago in Hungary where it is still called Hungarian brome grass. It thrives well on loose, sandy soil but on better soil larger yields may be expected. When well established it is not injured by spring and fall frosts. It should be remembered that this grass is often not easily eradicated, and it is, therefore, not specially adapted for use in a short rotation. In the western part of the State, it is highly prized for its sand-binding ability and for this purpose it is very often employed.

34. *Bromus kalmii*. Wild Chess. (Fig. 96.)

This is a rather stout perennial found in central and northwestern Nebraska.

35. *Bromus porteri*. Wild Chess. (Fig. 96.)

This species is very closely related to *Bromus kalmii*. It is a perennial found only in northwestern Nebraska.

36. *Bromus racemosus*. Smooth Brome Grass. (Fig. 98.)

A rather slender annual introduced from Europe. It produces hay of rather good quality. Lancaster County.

37. *Bromus secalinus*. Chess. (Fig. 98.)

This is a well-known introduced annual weed of grain fields and waste places and now found practically thruout Nebraska. It was introduced in agricultural seed into the various parts of the State. The idea commonly entertained by many farmers that wheat degenerates into Chess is utterly without foundation in fact.

38. *Bromus squarrosus*. (Fig. 97.)

Introduced from Europe and now reported from Box-butte and Howard Counties.

39. *Bromus tectorum*. (Fig. 92.)

A low tufted annual which is fast becoming a common weed in the eastern parts of the State. It was introduced from Europe.

BUCHLOE.

40. *Buchloe dactyloides*. Buffalo Grass. (Fig. 57.)

This, the genuine Buffalo Grass, is claimed to have formerly been much more abundant on the prairies than at the present time. It forms numerous, creeping, branch-

ing stolons, similar to those found in Bermuda grass, which root at the nodes, each joint thus forming a new tuft. Thus a close mat of fine leaves is formed which may cover considerable areas. It is unsurpassed for winter pasturage and is considered one of the best grasses for sheep pastures. Throuout the State, but most abundant in the western counties.

CALAMAGROSTIS.

41. *Calamagrostis canadensis*. Yellowtop. (Fig. 50.)

A stout native prairie grass of the western half of the State. It often occupies rather large areas to the exclusion of other grasses and may then yield considerable hay of fine quality. It grows best in rather low moist meadows and has done well under cultivation.

42. *Calamagrostis inexpansa*. (Fig. 50.)

A rather stout erect grass reported from Buffalo, Custer, and Thomas Counties.

43. *Calamagrostis neglecta*. Pony Grass. (Fig. 50.)

A rather slender, erect native perennial on prairies—more common in the western part of the State.

CALAMOVILFA.

44. *Calamorilfa longifolia*. Long-leaved Reed Grass. (Fig. 40.)

A stout long-leaved grass forming an extensive system of rhizomes. It is unsurpassed as a sand-binder for the semiarid regions tho of little or no forage value. Common in the Sand Hill region.

CATABROSA.

45. *Catabrosa aquatica*. Water Grass. (Fig. 70.)

A rather soft and weak aquatic grass of central and western Nebraska.

CENCHRUS.

46. *Cenchrus tribuloides*. Sand Bur. (Fig. 23.)

A common annual weed thruout the State. If cut before the "burs" are formed it makes good hay.

CINNA.

47. *Cinna arundinacea*. Wood Reed Grass. (Fig. 43.)

A tall native perennial common in woods and wet meadows—particularly in the eastern part of the State.

48. *Cinna latifolia*. (Fig. 43.)

A perennial somewhat smaller than the preceding species.

CYNODON.

49. *Cynodon dactylon*. Bermuda Grass. (Fig. 58.)

A creeping perennial that grows readily in poor, sandy soils where other grasses will not thrive. It is very widely cultivated in the South and should prove useful as a sand-binding grass in many places. It is extensively grown as a lawn grass in the South and is propagated thru the use of pieces of the sod.

DACTYLIS.

50. *Dactylis glomerata*. Orchard Grass. (Fig. 73.)

A valuable perennial introduced grass often found escaped from cultivation. It is a bunch grass and makes a rapid, early growth, producing an excellent quality of hay. Its common name is based upon the ability of the grass to make a good growth in shady situations. To counteract its well-known tendency to form tussocks, often considerably raised above the ground, it should be sown with some other grass, preferably awnless brome grass or meadow fescue. It cannot be recommended for the drier soils of western Nebraska.

DESCHAMPSIA.

51. *Deschampsia flexuosa*. Wood Hair Grass. (Fig. 56.)

A slender, erect, native perennial of little value except in woodland pastures as it grows well in shaded ground. It yields an inferior coarse forage which, when young, is eaten by stock. It shows a tendency to form tussocks.

DIARRHENA.

52. *Diarrhena diandra*. (Fig. 66.)

In moist shaded places in eastern Nebraska.

DIGITARIA.

53. *Digitaria sanguinalis*. Crab Grass. (Fig. 21.)

This is a well-known introduced annual often found in cultivated fields and constituting, particularly in eastern Nebraska, one of our worst lawn weeds. During the latter part of the season it makes a very rapid growth and may take absolute possession of a lawn. It is less common in the western counties.

DISTICHLIS.

54. *Distichlis spicata*. Salt Grass. (Fig. 73.)

This is an erect wiry grass with an extensive system of

rootstocks which often form such a compact sod as to render it a nuisance in farming lands. It is a good sand-binder, but otherwise has no agricultural value. It thrives in alkali soils even when the ground is heavily crusted with alkali. Thruout the State.

ECHINOCHLOA.

55. *Echinochloa crus-galli*. Barnyard Grass. (Fig. 22.)

This is a rank-growing annual weed well-known in rich, cultivated ground, particularly about dwellings. It is so thoroly dispersed thruout the State as sometimes to appear to be indigenous. The species presents several quite distinct forms, each having its own peculiar qualities. One of these has been cultivated in several places and is valuable for green feed and silage, but is too coarse and succulent to make good hay.

ELEUSINE.

56. *Eleusine indica*. Goose Grass. (Fig. 58.)

A coarse tufted annual generally regarded as a weed, particularly in lawns and about dwellings. Introduced from Europe and not common.

ELYMUS.

57. *Elymus canadensis*. Wild Rye Grass. (Fig. 112.)

A stout, smooth perennial which probably has some agricultural value altho it has not been very thoroly tested. It is very abundant on the prairie, low flats, and along the smaller streams thruout the State. When cut early it should form a good quality of hay, tho the frequent presence of "ergot" might render its use for this purpose dangerous.

58. *Elymus condensatus*. Giant Rye Grass. (Fig. 108.)

A stout tufted perennial grass of central Nebraska common in wet alkali soils and along streams, the banks of which are often protected from erosion by its rootstocks. This grass should also be of service as a sand-binding grass along railroads, etc. When young it makes good hay and when allowed to stand it provides considerable winter forage on the range.

59. *Elymus glaucus*. (Fig. 113.)

In moist soil. Central Nebraska.

60. *Elymus macounii*. Macoun's Lyme Grass. (Fig. 113.)

A perennial grass of northwestern Nebraska.

61. *Elymus robustus*. (Fig. 112.)

A stout leafy perennial in rich moist soil in central and western Nebraska.

62. *Elymus striatus*. Dennett Grass. (Fig. 110.)

A slender tufted perennial of the central and northern counties.

63. *Elymus virginicus*. Lyme Grass. (Fig. 111.)

A stout perennial of the eastern and northern counties.

ERAGROSTIS.64. *Eragrostis capillaris*. (Fig. 79.)

An erect tufted grass of dry fields in eastern Nebraska.

65. *Eragrostis hypnoides*. Creeping Meadow Grass. (Figs. 80, 82.)

This grass has prostrate much-branched stems. Occurs in low wet places, particularly along streams in eastern Nebraska.

66. *Eragrostis megastachya*. Stink Grass. (Fig. 83.)

A showy much-branched annual which emits, when fresh, a strong unpleasant odor. A common weed thruout the State.

67. *Eragrostis pectinacea*. Comb Grass. (Fig. 81.)

A rather pretty weed common in dry fields except in the extreme western part of the State.

68. *Eragrostis pilosa*. Slender Meadow Grass. (Figs. 80, 82.)

A slender decumbent introduced grass occasional in waste places. Lancaster and Sheridan Counties.

69. *Eragrostis trichodes*. Blow-out Grass. (Fig. 83.)

This is a pretty grass of sandy soils and in blow-outs in central and western Nebraska. It has given good results under cultivation and promises well as a hay grass tho the foliage is rather wiry.

ERIOCOMA.70. *Eriocoma cuspidata*. Indian Millet. (Fig. 38.)

A rather slender native perennial bunch grass which thrives in dry sandy soil, even in typical sage-brush land, and is much esteemed for grazing. Western Nebraska.

FESTUCA.71. *Festuca altaica*. Rough Fescue Grass. (Fig. 89.)72. *Festuca elatior*. Meadow Fescue. (Fig. 90.)

This perennial grass is a native of Europe, but has long

been cultivated in various parts of the United States and is now thoroly naturalized. Its drouth-resistance recommends it for use in Nebraska where it can be employed as a pasture grass. Sowing with orchard grass has proved successful. It does best on moist soils rather rich in humus.

73. *Festuca obtusa*. (Fig. 90.)

A rather stout, erect, glabrous perennial in open woods and thickets of the eastern counties.

74. *Festuca octoflora*. Slender Fescue. (Fig. 89.)

An erect annual, in sandy soil thruout the State.

75. *Festuca ovina*. Sheep's Fescue. (Fig. 89.)

An erect, tufted perennial found on prairies thruout the State and apparently indigenous in many places.

GLYCERIA.

76. *Glyceria grandis*. Reed Meadow Grass. (Fig. 76.)

An erect, tall aquatic grass of the Sand Hill region of central and northern Nebraska.

77. *Glyceria nervata*. Fowl Meadow Grass. (Fig. 76.)

An erect aquatic grass widely distributed.

HOLCUS.

78. *Holcus lanatus*. Velvet Grass. (Fig. 55.)

An introduced perennial. It is not liked by stock, but may be of some value on soils where better grasses will not grow. Generally considered a weed.

HORDEUM.

79. *Hordeum jubatum*. Squirreltail Grass. (Fig. 114.)

A striking and rather pretty annual weed found thruout the State.

80. *Hordeum pusillum*. (Fig. 114.)

A slender erect perennial in dry or alkaline soils thruout the State.

HYSTRIX.

81. *Hystrix patula*. Bottle Brush. (Fig. 102.)

A slender tufted perennial of fertile moist soils of eastern Nebraska.

KOELERIA.

82. *Koeleria cristata*. Prairie June Grass. (Fig. 70.)

An erect, perennial bunch grass of the prairies and open meadows. For early forage it has some value and

under irrigation it makes good hay tho the yield is low. Common thruout the State.

LEERSIA.

83. *Leersia oryzoides*. Rice Cut Grass. (Fig. 31.)

A rather stout grass in wet soils thruout the State.

84. *Leersia virginica*. Virginia Cut Grass. (Fig. 31.)

A slender decumbent grass common in wet soils thru the eastern counties, but not found in the extreme western part of the State.

LOLIUM.

85. *Lolium multiflorum*. Italian Rye Grass. (Fig. 104.)

A biennial or perennial introduced plant and one of our well-known hay grasses for rich and rather moist lands, particularly in the eastern counties. It is a rapid grower and forms a good turf. It starts earlier, grows more rapidly, and has lighter green foliage and taller, coarser stems than the Perennial Rye Grass. For temporary meadows it can be recommended but is of too short duration for permanent pastures. The seed is generally rather free of impurities and can ordinarily be secured on the market.

86. *Lolium perenne*. Perennial Rye Grass. (Fig. 104.)

This perennial has been cultivated in England for upward of two centuries. Like the Italian Rye Grass it prefers moist and rich loam and clay soils. In this region it cannot be considered as at all the equal of timothy for hay or other purposes.

87. *Lolium temulentum*. Bearded Darnel. (Fig. 104.)

An erect generally rather stout annual in waste places and cultivated grounds.

MELICA.

88. *Melica nitens*. Melic Grass. (Fig. 71.)

An erect grass found at a very few points in eastern Nebraska.

MUHLENBERGIA.

89. *Muhlenbergia mexicana*. Wood Grass. (Fig. 49.)

A much-branched, spreading or ascending grass found in shaded meadows and along streams in many parts of the State.

90. *Muhlenbergia pungens*. Blow-out Grass. (Fig. 47.)

A tufted rigid native perennial in dry soils of the Sand Hills and prairies of western Nebraska.

91. *Muhlenbergia racemosa*. Wild Timothy. (Fig. 49.)

This is an upright, sparingly-branched perennial with rootstocks covered with thick scales. It is an excellent hay grass when grown under suitable conditions. Common in wet soil thruout the State.

92. *Muhlenbergia schreberi*. Nimble Will. (Fig. 49.)

A prairie grass. Cherry, Holt, Lancaster, and Valley Counties.

93. *Muhlenbergia sylvatica*. (Fig. 49.)

A perennial in woods and on banks of streams. Harlan County.

94. *Muhlenbergia tenuiflora*. (Fig. 49.)

An erect perennial in rocky woods. Webster County.

MUNROA.

95. *Munroa squarrosa*. False Buffalo Grass. (Fig. 63.)

A low much-branched annual not liked by stock. Common in the Sand Hill region and often found in blow-outs.

ORYZOPSIS.

96. *Oryzopsis micrantha*. Mountain Rice. (Fig. 38.)

A slender erect perennial in woods and along streams in the extreme northern and western counties.

PANICUM.

97. *Panicum barbipulvinatum*. (Fig. 28.)

An erect grass freely branching at the base. Common in the western counties.

98. *Panicum capillare*. Old Witch Grass. (Fig. 28.)

This is an annual with coarse branching stems and hairy leaf sheaths. In cultivated ground it often becomes a troublesome weed. For fall feed on stubble it may have some value. Common thruout the State.

99. *Panicum dichotomiflorum*. (Fig. 27.)

A weedy annual grass of the eastern counties.

100. *Panicum huachucae*. (Fig. 29.)

In prairies. Buffalo, Cherry, Hall, and Holt Counties.

101. *Panicum leibergii*. (Fig. 30.)

A slender perennial in dry or moist soil. Dixon and Stanton Counties.

102. *Panicum miliaceum*. European Millet. (Fig. 28.)

This is a branching annual which has long been cultivated in Asia and Europe and to a limited extent in the United States. When cut in flower it furnishes a large amount of excellent green feed for stock.

103. *Panicum praecocius*. (Fig. 29.)

On dry prairies. Custer and Hall Counties.

104. *Panicum scribnerianum*. (Fig. 30.)

An erect branching perennial thruout the State.

105. *Panicum virgatum*. Switch Grass. (Fig. 27.)

A stout, erect, unbranched perennial found on prairies thruout the State. When cut before ripe it produces a very valuable hay.

106. *Panicum wilcoxianum*. Wilcox's Panic Grass. (Fig. 30.)

Common in the Sand Hill region of central Nebraska.

PASPALUM.

107. *Paspalum stramineum*. Beard Grass. (Fig. 22.)

A perennial frequent in sandy soil thruout the State.

PHALARIS.

108. *Phalaris arundinacea*. Reed Canary Grass. (Fig. 32.)

A stout perennial of wet soil widely distributed thruout the State, particularly in the eastern counties.

109. *Phalaris canariensis*. Canary Grass. (Fig. 32.)

An erect annual grass often found along streets in towns. Boxbutte, Kearney, and Lancaster Counties.

PHLEUM.

110. *Phleum pratense*. Timothy. (Fig. 34.)

This is the best known and most largely cultivated hay grass in the northern States where it has become thoroly naturalized. On dry soils only light yields can be expected. It is often sown with other grasses or one of the clovers.

PHRAGMITES.

111. *Phragmites communis*. (Fig. 64.)

One of the tallest of our native grasses. in ponds and along streams thruout the State. The stems often run along the ground for as much as 40 feet, striking root at each node.

POA.

112. *Poa annua*. Low Spear Grass. (Fig. 85.)

A low spreading, introduced annual weed which has made its appearance in eastern Nebraska.

113. *Poa compressa*. Canada Blue Grass. (Fig. 86.)

This is a slender perennial of bluish-green foliage often confounded with the genuine Kentucky Blue Grass from which it may be distinguished by its flattened, decumbent, wiry stems, shorter leaves and shorter, narrower and smaller panicles. It is adapted to somewhat more sterile soil than Kentucky blue grass, but on the whole it is scarcely to be recommended for Nebraska. Thruout the State but not common.

114. *Poa nemoralis*. Spear Grass. (Fig. 87.)

A tufted, erect, perennial grass of western Nebraska.

115. *Poa pratensis*. Kentucky Blue Grass. (Fig. 87.)

This is a well-known perennial grass native of parts of North America and now much grown as a pasture grass. It is in fact the champion pasture grass of the limestone region of Tennessee and Kentucky. With us it is universally employed as a lawn grass where it makes a firm sod. It is better adapted for use in pastures than as a hay crop. However, it is a shallow-rooted plant, not at all suited to drouthy conditions.

POLYPOGON.

116. *Polypogon monspeliensis*. Beard Grass. (Fig. 34.)

An introduced plant in fields and waste places. Kearney County.

PUCCINELLIA.

117. *Puccinellia airoides*. (Fig. 76.)

A tufted perennial in alkali soil. Cheyenne, Dawes, and Sioux Counties.

REDFIELDIA.

118. *Redfieldia flexuosa*. Blow-out Grass. (Fig. 68.)

This is a stout perennial native to the sandy soils of the West. Its deeply penetrating and widely spreading rootstocks render it the sand-binding grass par excellence. It is in fact a typical blow-out grass well worthy of trial where drifting sand becomes troublesome. A common grass thruout the Sand Hill region.

SCHEDONNARDUS.

119. *Schedonnardus paniculatus*. Wild Crab Grass. (Fig. 59.)
A low weedy grass in dry places thruout the State.

SCOLOCHLOA.

120. *Scolochlou festucacea*. Sprangle Top. (Fig. 74.)
A stout, erect perennial in wet ground or shallow water.
Grant County.

SETARIA.

121. *Setaria glauca*. Yellow Foxtail. (Fig. 25.)
An erect annual and, like *Setaria viridis*, often appearing in quantities as a weed in alfalfa fields where it has been introduced in alfalfa seed. A common weed thruout the State, but most abundant eastward.
122. *Setaria verticillata*. Bristly Foxtail. (Fig. 24.)
An introduced annual weed often found near dwellings. Its bristles are barbed downward, and this feature enables its heads to cling to clothing and other objects. In the eastern part of the State but not common.
123. *Setaria viridis*. Green Foxtail. (Fig. 25.)
A common weed of fields and waste places where it flowers somewhat earlier than the yellow foxtail from which it may further be distinguished by its greenish bristles. It is a common annual weed found thruout the State.

SITANION.

124. *Sitanion hystrix*. Wild Rye Grass. (Fig. 103.)
A low tufted perennial species of western Nebraska, resembling somewhat squirreldtail grass. Dry soil in western part of the State.

SORGHASTRUM.

125. *Sorghastrum nutans*. (Fig. 17.)
Common on prairies thruout the State and of considerable value for hay. It is a stout perennial forming a large proportion of our western prairie hay. Its long root-leaves provide forage of good quality. During dry weather it does not seed freely. It does best on the richer prairie bottoms.

SPARTINA.

126. *Spartina gracilis*. Little Cord Grass. (Fig. 62.)
A pretty grass of western Nebraska in saline marshes, but of little or no value for forage.

127. *Spartina michauxiana*. Slough Grass. (Fig. 62.)

This grass makes a rather coarse hay and must be cut when young. It is well adapted for sand binding on account of its strong, scaly rootstock. In wet places thruout the State—but most common in the southeastern counties.

SPHENOPHOLIS.

128. *Sphenopholis obtusata*. Early Bunch Grass. (Fig. 77.)

A tufted perennial—often growing in moist soil. It is readily eaten by stock and supplies a considerable amount of forage of good quality. Common on prairies thruout the State.

129. *Sphenopholis pallens*. Eaton's Grass. (Fig. 77.)

On wooded bluffs thruout the State.

SPOROBOLUS.

130. *Sporobolus asper*. (Fig. 52.)

Sandy soil thruout the State.

131. *Sporobolus asperifolius*. Prairie Grass. (Fig. 54.)

A low perennial grass of dry prairies in the western half of the State.

132. *Sporobolus brevifolius*. (Fig. 52.)

An erect, slender, tufted grass in dry soil—thruout the State.

133. *Sporobolus confusus*. Prairie Grass. (Fig. 54.)

An annual found only in western Nebraska.

134. *Sporobolus cryptandrus*. Prairie Grass. (Fig. 54.)

A common perennial grass of dry sandy prairies—thruout the State.

135. *Sporobolus heterolepis*. Wire Grass. (Fig. 54.)

Not common, tho found occasionally in eastern and northern Nebraska.

136. *Sporobolus neglectus*. Small Rush Grass. (Fig. 52.)

In dry soil. Brown County.

137. *Sporobolus vaginiflorus*. Southern Poverty Grass. (Fig. 52.)

An annual grass of roadsides and waste places in eastern Nebraska.

STIPA.

138. *Stipa comata*. Needle Grass. (Fig. 46.)

A well-known grass of the High Plains of western Nebraska. It is often very troublesome to sheep and other domestic animals.

139. *Stipa spartea*. Porcupine Grass. (Fig. 46.)

This resembles the preceding species, but is stouter and like it is a great pest to sheep. It is most abundant in the eastern Nebraska prairies.

140. *Stipa viridula*. Feather Bunch Grass. (Fig. 46.)

Occurs thruout the State—particularly in western counties.

TRIPLASIS.

141. *Triplasis purpurea*. Sand Grass. (Fig. 67.)

A low annual grass of the Sand Hill ravines of northwestern Nebraska.

TRIPSACUM.

142. *Tripsacum dactyloides*. Gama Grass. (Fig. 13.)

A stout, coarse, perennial of moist soil in southeastern Nebraska. When young it is much liked by stock.

ZIZANIA.

143. *Zizania aquatica*. Indian Rice. (Fig. 31.)

An annual grass growing in ponds and along streams thruout the State. The nutritious grain is often eaten by birds.

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H. A. McCOMB, B. Sc., *Horticulturist of Experimental Substation, North Platte*.
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J. A. RATCLIFF, B. Sc., *Assistant in Experimental Agronomy*.
L. B. STURDEVANT, A. M., M. D., *Assistant in Animal Pathology*.
E. G. WOODWARD, A. M., *Assistant in Dairy Husbandry*.
J. R. COOPER, B. Sc., *Assistant in Horticulture*.
C. A. HELM, B. Sc., *Assistant in Experimental Agronomy*.
FLORENCE A. McCORMICK, PH. D., *Assistant in Agricultural Botany*.
H. E. VASEY, A. M., *Assistant in Agricultural Botany*.
JAMES COWAN, M. E., *Superintendent Experimental Substation, Valentine*.
FRITZ KNORR, B. Sc., *Superintendent Experimental Substation, Mitchell*.
H. L. NYE, *Foreman Demonstration Farm, Culbertson*.

*Resigned.

RAISING THE DAIRY CALF.

BY E. G. WOODWARD.

WHAT IS THE IMPORTANCE OF RAISING DAIRY CALVES?

There are in Nebraska more than 600,000 dairy cows. The average period of usefulness of the dairy cow is not more than eight years. This means that to maintain the dairy herds of Nebraska at their present size between 70,000 and 80,000 heifer calves must be raised each year. To mate these cows properly with dairy bred bulls will require the rearing of about 8,000 bulls yearly.

Aside from the necessity of maintaining the herds at their present size, the importance of calf raising to the Nebraska dairyman lies in the fact that this is the surest and most satisfactory way of improving his herd. It should be remembered, first, that herd improvement can come only thru the replacing of worn-out or discarded cows by heifers better than the cows they replace. Such heifers are the result of mating a pure-bred bull with a herd of cows from which the undesirable individuals have been culled. It is neither practical nor satisfactory for the dairyman to buy these heifers, because he will usually have to pay more for them than it would cost to raise them, and he has no assurance that heifers which he may buy are well bred.

WHEN DOES IT PAY TO RAISE A CALF?

The dairyman's main object in raising calves should be to improve his herd. He may also raise stock for sale either for breeding or for slaughter. Under ordinary conditions it will pay to raise every well-bred heifer calf. Heifer calves of inferior breeding and grade bull calves or pure-bred bulls of inferior breeding should not be raised with the intention of using them for breeding purposes. Unless conditions are such that it will pay to raise these for meat it is best to kill such calves at birth. Then they will not leave any inferior offspring in the country.

In order to determine what gains may be produced on dairy calves by the use of skim milk and home grown feeds, three dairy

steers were fed from birth up to about one year of age. Whole milk was fed for about three weeks. The grain consisted of a mixture of 200 pounds of corn chop and 100 pounds of ground oats. The results were as follows:

TABLE 1.—*Showing results of feeding three dairy steer calves skim milk up to the age of one year.*

Calf	Age	Whole milk	Skim milk	Alfalfa hay	Grain	Birth weight	Final weight	Daily gain
	<i>Days</i>	<i>Lbs.</i>	<i>Lbs.</i>	<i>Lbs.</i>	<i>Lbs.</i>	<i>Lbs.</i>	<i>Lbs.</i>	<i>Lbs.</i>
Jersey	360	258	5,958	1,609	1,178	60*	580	1.44
Holstein-Jersey ...	384	251*	6,366	1,696	1,652	48	750	1.83
Grade Holstein ...	344	245	5,620	1,584	1,238	74	700	1.82

*Estimated.

WHAT IS THE COST OF FEED REQUIRED TO RAISE A CALF?

Where skim milk is available, as it is on most of the farms in Nebraska where dairying is followed, the cost of feed for raising a fall calf will be about as follows:

TABLE 2.—*Showing feed requirement to raise a calf up to the age of six months when skim milk is used.*

Feed	Amount	Price	Value
Whole milk	175 lbs.	\$1.50 per cwt.	\$2.63
Skim milk	2,700 lbs.	.25 per cwt.	6.75
Grain	125 lbs.	1.00 per cwt.	1.25
Hay	450 lbs.	10.00 per ton	2.25
			\$12.88

At the age of six months a skim milk calf should weigh from 250 to 400 pounds, depending upon the size of the breed and the thrift of the calf. Whether or not it will pay to raise steer calves of the dairy breeds or the inferior dairy heifers for meat will depend entirely upon conditions.

In some places whole milk is sold and skim milk is not available. If a calf is raised on whole milk by shortening the milk feeding period to about three months, the cost of feed will be about as follows:

TABLE 3.—*Showing the feed required to raise a calf up to the age of six months when a small amount of whole milk is used.*

Feed	Amount	Price	Value
Whole milk	900 lbs.	\$1.50 per cwt.	\$13.50
Grain.....	250 lbs.	1.00 per cwt.	2.50
Hay	600 lbs.	10.00 per ton	3.00
			\$19 00

It may even be possible to raise calves on whole milk with less feed than that mentioned, but in any case the results will be less satisfactory than when skim milk is used and the feeding prolonged to six months.

THE CALF AT BIRTH.

Every precaution should be taken to give the cow about to freshen the most cleanly and sanitary surroundings possible. The cow should be allowed to calve in a clean, freshly bedded stall, or better yet in mild weather, in the pasture. It is essential that surroundings be clean in order to avoid infection of the freshly severed navel cord. The cow will be in better physical condition and will yield more milk if she is dried up about six weeks before calving time than she would if milked up to the time of calving.

RAISING A CALF ON SKIM MILK.

It is now fairly well understood that calves properly raised on skim milk are equally as growthy, thrifty, and vigorous as



Fig. 1.—Skim milk calves.

those raised upon whole milk or those allowed to run with their dams. In fact the skim milk calf will oftentimes show a more rugged framework than a calf raised on whole milk. It is usual, however, for the whole milk calf to appear smoother and more plump, due to the fact that it lays on a greater amount of body fat than the calf fed skim milk.

Except for the fat that has been removed, skim milk is identical in composition with whole milk. When whole milk is taken into the calf's body, the fat of the milk is used to produce heat to keep the calf warm and also to form body fat. This same function can be performed very much more cheaply by starchy grains such as corn, Kafir corn, and oats.

The protein of milk, which is the constituent most concerned in muscular growth and the building up of the vital organs, is equally as abundant in skim milk as in whole milk.

TAKING THE CALF FROM THE COW.

It matters little whether the calf is taken from the cow immediately after being dropped or is allowed to stay with its mother for several days. The essential thing is that the calf receive the first milk from its mother. A calf should always receive the milk from its own mother for the first two or three days of its life, because the milk is quite unlike normal milk and stimulates the calf's digestive tract to action.

The earlier the calf is taken from its mother the easier will it be to teach it to drink. When the calf runs with its mother for several days it will learn to drink more quickly if it is not offered milk for 24 to 36 hours after it has been separated from the cow. In most cases the calf will learn to drink quite readily if allowed to suck the feeder's fingers while they are held under the milk.

FEEDING WHOLE MILK.

The stomach of the young calf is small, so that it is not able to handle large amounts of milk. Eight to 10 pounds or 4 or 5 quarts per day is the proper amount to feed a young calf. For a very small or weak calf, 6 pounds or 3 quarts is sufficient. The results are probably a little better when the calf is fed three times daily for the first few days. This is not necessary, however, and it is usually best not to feed three times daily unless the milk can be obtained fresh from the cow for each feed. The milk should be divided equally between the feeds so that a calf being fed twice daily would receive 4 or 5 pounds at each feed.

FEEDING SKIM MILK.

A calf of ordinary vigor can be put on a skim milk diet at the age of two or three weeks. The change to skim milk should be gradual. This change is best made by substituting a pound of skim milk for a pound of whole milk at each feed until the calf is receiving only skim milk.



Fig. 2.—Calves about two weeks old. These are old enough to be fed skim milk.

The amount of skim milk fed should be the same as that of the whole milk which it replaces. This will usually be 10 or 12 pounds for a calf two to three weeks old. A gradual increase in the milk should be made as the calf grows, until at the age of five months it is receiving 16 to 20 pounds daily, depending upon the size of the calf.

FEEDING GRAIN.

The calf will begin to eat a little grain by the time it is two or three weeks old. After it is a few days old, grain should be kept before it and a little put into its mouth immediately after it has finished drinking its milk to aid it in learning to eat.

The grain should always be fed dry and never mixed with the milk. In order that grain be properly digested it is necessary that it be chewed before it is swallowed. Probably the best time to feed the grain is just after the milk has been fed. The calf's appetite is very keen at this time, and it will take to the grain readily.

A good grain mixture to use until the calf has learned to eat well is two parts ground corn and one part crushed oats. When the calf has learned to eat, shelled corn alone will give as good results as any grain that can be supplied.

Up to the age of three months it is well to give the calf all the grain it will eat. At that time it will be eating two to three

pounds daily and may very well be limited to this amount until weaning time.

FEEDING HAY.

The calf will begin to eat hay at about the same time as it does grain, and some should be provided for it to nibble.

For the young calf, clover or mixed hay is as good as any. It occasionally happens that where alfalfa hay of the best quality is fed immediately after the milk and grain a calf will gorge itself to such an extent that impaction of the stomach may follow and prove fatal. When very palatable hay is fed, it is well either to supply it in limited amounts or to keep it before the calves all of the time so that they will not gorge themselves at any one time. In any case it is best to feed the hay during the middle of the day and not immediately after the milk and grain has been fed, as such a great bulk all at once proves a severe tax on the digestive system.

FEEDING SILAGE.

Silage may be fed with safety to the young calf, and is very much relished by it. It is well to pick the pieces of ear out of the silage fed a young calf. In using silage avoid overloading the calf's digestive system either by offering even only a small amount or supplying it in the middle of the day.

WATER AND SALT.

It is a mistake to assume that a calf does not require water because it is receiving skim milk. The calf should have water accessible at all times, as it will drink considerable despite the fact that it is receiving a large quantity of milk.

It is also quite necessary that the calf be provided with salt. It requires salt besides its regular feed, the same as does an older animal.

WEANING.

Six months is a very good age at which to wean a calf, tho



Fig. 3.—Calves about six months old. These calves are ready to be weaned.

there is no reason why the feeding of milk should not be prolonged beyond this time if skim milk is abundant. A calf can be weaned in three or four days' time by gradually reducing the amount fed.

SCOURS.

Scours in calves are by far the most common sources of trouble in calf raising. If a feeder is able to avoid the occurrence of scours in his calves, it is very seldom that other ailments will annoy. Scours in calves are of two kinds.

WHITE SCOURS.

White scours, or calf cholera, is an infectious disease. The germ of this disease enters the blood of the calf soon after birth thru the freshly severed navel cord. This disease always attacks very young calves, usually appearing within three days after birth. It is characterized by the whitish, foul-smelling dung which the calf passes and a depressed, hollow-eyed appearance in the calf. It is nearly always fatal, and as yet no treatment has been found which will give good results. About the only practical thing that can be done is to avoid the occurrence of this disease by keeping the surroundings of the newborn calf in a sanitary condition. The cow should be allowed to calve in a clean, freshly bedded stall; or in mild weather, in the open pasture. If this disease has occurred on the farm previously, it is well to disinfect the navel cord and belly of the freshly born calf with a 3 per cent solution of creolin or 3 per cent carbolic acid and bind the cord up to the belly with a wide strip of muslin to avoid later infection.

SCOURS FROM INDIGESTION.

The common cause of scours is indigestion, or inflammation in the stomach. This may be brought about by a large variety of causes, but in any case the aim of the treatment should be to remove the source of the inflammation. As in most other ailments, half of the battle in curing scours is to begin treatment as soon as any trouble is noticed. The calves should be watched closely and treatment administered upon the first indications of scours. Treatment should always begin by cutting down the ration, thus giving the calf a chance to rid itself of the irritating material. The milk should be cut down at least one-half and in severe cases withheld entirely. In most cases after one or two feeding periods have passed, the calf will appear normal, and full feeding can be gradually resumed.

In more obstinate cases it may be necessary to administer a

physic of 2 or 3 ounces of castor oil given in a little milk. After a calf has suffered with scours, feeding should always be light for a few days until the calf regains its strength.



Fig. 4.—This picture shows the effect of scours on the growth of a calf. These are both pure-bred Jersey calves. The calf at the left of the picture is 34 days older than the calf at the right but weighs less. When about two weeks old it suffered from a very severe attack of scours and has not fully recovered from the effect.

SPECIAL POINTS TO OBSERVE.

Common scours give more trouble in calf raising than any other one thing. Scours may be caused or at least favored by a variety of conditions.

CONDITION OF THE MILK.

To avoid scours it is essential that the condition of the milk be controlled. Milk should always be fed sweet if good results are to be obtained. While it is known that healthy, vigorous calves may be raised on sour milk, it is not a good policy to try to feed it, because it is often impossible to obtain properly soured milk. Milk that has been allowed to stand around until it is half rotten is quite different from normal sour milk tho it may have a sour taste, and it is almost sure to cause trouble if fed to calves. Sweet milk is very much more dependable in quality and should therefore be used exclusively.

CLEANLINESS OF PAILS AND UTENSILS.

Scours are often caused, no doubt, by a filthy condition of the feeding pail or trough. Unclean milk or milk out of unclean

vessels will cause trouble. It is best to give the calf pails the same treatment and attention accorded the regular milk pails. They should be kept sweet smelling.

TEMPERATURE OF THE MILK.

Milk should always be fed at a temperature near that of blood heat, or between 95° and 100° F. This is the temperature at which the calf would receive the milk if it were sucking the cow. Cold milk taken into a young calf's stomach so chills it that digestive processes are checked for a time and digestive disturbances are liable to follow.

Calves that have reached the age of two and one-half or three months may be fed milk somewhat colder than 95°, but in any case the temperature should be constant and a calf should not receive warm milk at one feed and cold milk at the next.

A thermometer should actually be used in testing the temperature of the milk—at least often enough so that the temperature can be estimated fairly accurately.

OVERFEEDING.

Probably the most frequent cause of scours is overfeeding. When properly fed the appetite of the calf will be more keen after taking its milk than before. It is impossible to satisfy a calf's appetite for milk without overfeeding it. Overfeeding at any



Fig. 5.—Calves in stanchions at feeding time. The milk is weighed for each calf. Each calf receives the proper amount and no more.

particular feed is best guarded against by actually weighing the milk at each feed or measuring it in a vessel sufficiently small to avoid guesswork. Weighing is to be preferred, as the foam which occurs on separator milk makes accurate measuring difficult.

If several calves are being fed in the same pen it is best to have ties of some sort for them so that each calf may receive only its apportioned feed. For this purpose small, rigid stanchions are the most convenient. If the calf is kept tied until after the grain is eaten, there is less likelihood of it forming the habit of sucking other calves' ears.

Overloading the calf's stomach in the morning and evening should be avoided by feeding the roughage thru the middle of the day.

FEEDING FOAM TO CALVES.

On skim milk fresh from the separator there is always more or less foam. Large quantities of this foam fed to a calf will cause it to become bloated and may even cause sickness. The little that the calf will ordinarily receive with its milk will cause no trouble.

CALF PENS AND LOTS.

Dirty, muddy, or uncomfortable quarters are favorable to scours. Calves should not be turned out into muddy or wet lots where they will not have a dry place in which to lie. In fact young calves up to three or four months of age will thrive fully as well in a roomy, clean, and well-lighted stall as on pasture. The young calf should be especially protected from quick changes in temperature and cold drafts, which are liable to bring on pneumonia.

VIGILANCE ON THE PART OF THE FEEDER.

One very important rule to follow in calf feeding is to be constantly on the lookout for disorders. Prevention of sickness is far better than curing it. The feeder should always observe the keenness of the calf's appetite and the character of the dung. At the slightest hint of any disturbance the amount of milk should be cut down.

DEHORNING THE CALF.

Dairy cows should be dehorned, because dehorning makes a cow more docile, easier to handle and feed, and also makes it impossible for her to injure the udders of other cows with her horns.

Possibly the most satisfactory way to dehorn a calf is to apply caustic potash. Caustic potash can be obtained at almost any

drug store. It usually comes in the form of sticks about the size of a lead pencil. The calf should be treated when one or two days old or as soon as the starting horn can be located.

To dehorn the calf, clip the hair from the spot where the horn is starting. Then wet the end of a stick of caustic potash and



Fig. 6.—This calf was dehorned by means of caustic potash. The poll is perfectly smooth.

rub on the budding horn until a sore spot about the size of a dime is produced. The operation can be hastened by breaking the skin before rubbing on the potash. The calf should not be turned out into the rain immediately after caustic potash has been applied, as it may be washed down into the calf's eyes.

Caustic potash should be handled by wrapping a piece of paper around the stick. It must be kept in a tightly stoppered bottle, or it will absorb water from the air and dissolve.

RAISING A CALF WITH WHOLE MILK.

Where whole milk is sold and none of the milk is skimmed, the raising of calves is decidedly more expensive than where skim milk is abundant. Ordinarily the calf must be fed milk until it is two and one-half or three months old before it can be expected to live on a grain and hay diet. This will require 750 to 1,000 pounds of milk, worth at \$1.50 per hundredweight from \$11.25

to \$15. After the first two or three weeks, a calf will do equally as well on skim milk as on whole milk, so the expense can be cut down possibly one-third to one-half by skimming the milk and selling the butter fat.

A calf two and one-half to three months old is able to get along without milk if fed liberally of grain. The gains, however, will not be so satisfactory as those of a calf weaned at a later age. For the calf after weaning at this age, alfalfa hay, silage, and 3 or 4 pounds of a grain mixture made up of 2 pounds corn chop, 2 pounds ground oats, and 1 pound oil meal is very good to use for two or three months. However, the practice of weaning a calf so early is not to be recommended.

RAISING A CALF WITHOUT MILK.

It has been found possible by careful handling to raise calves without milk after three or four weeks old. Such calves are usually badly stunted but may recover from the effects to some extent if well fed in later life. It is not practical to raise calves in this way.

CARE OF THE DAIRY HEIFER.

Altho the first few months of the heifer's life is the most critical period of her existence, still many heifers are stunted, due to lack of attention after being weaned.

THE EFFECT OF TIME OF BIRTH ON GROWTH.

It is a rather common practice to have cows calve in the spring, yet this is not usually the best time. It is a fact that a calf born in the fall will get a better start in life than one born in the spring.

It makes little difference in the rate of growth of a calf whether it has pasture or has only dry feed in connection with its milk. But after weaning time the calf that has pasture will make by far the cheaper and more rapid growth. A fall calf will also be ready for breeding so that it will drop its own calf in the fall at the age of about two years.

Furthermore, a cow will give best returns when freshening in the fall. This is true because it is usually easier to maintain a steady flow of milk thru the winter and early spring than during the summer and fall. Also, dairy products demand highest prices during the winter.

FEEDING.

Until a calf is weaned it receives a liberal allowance of protein in its milk, but when milk is removed from the ration it is necessary to supply protein in some other form, such as legume

hay or a high protein concentrate. It is advisable to keep the heifer in a thrifty, growing condition, altho there is no need of fattening her. However, if she does become rather plump it will not injure her dairy qualities.



Fig. 7.—Well-grown dairy heifers in good, thrifty condition.

If fed so as to induce a thrifty growth yet not produce fat, dairy heifers will gain on an average close to 1 pound daily from the age of six months up to two years or calving time.

RATIONS FOR HEIFERS FROM SIX TO TWELVE MONTHS OLD.

Ration I.—About 2 pounds daily of a mixture of 75 pounds corn chop and 25 pounds bran; all the alfalfa hay the heifer will eat.

Ration II.—Six to 10 pounds silage; about 2 pounds daily of a grain mixture of 40 pounds corn chop, 40 pounds linseed meal or cottonseed meal, and 20 pounds bran; all the alfalfa hay the heifer will eat.

RATIONS FOR HEIFERS ONE TO TWO YEARS OLD.

Ration I.—About 3 pounds of corn daily; all the alfalfa hay the heifer will eat.

Ration II.—Corn silage, 12 to 20 pounds; about 3 pounds daily of a grain mixture of equal parts corn chop, bran, and linseed meal or cottonseed meal; all the alfalfa hay the heifer will eat.

BREEDING.

The proper age at which to breed a heifer will depend very largely upon the size and thrift of the animal as well as upon the breed.

Jersey or Guernsey heifers mature more rapidly than Holsteins or Ayrshires and hence are ready for breeding at an earlier age. The approved practice is to breed a Jersey or Guernsey

heifer at the age of 13 to 17 months. A Holstein or Ayrshire heifer if in good thrift may well be bred at the age of 17 to 21 months.

THE YOUNG BULL.

Nothing has been said about the bull calf, but his treatment should be the same as that of a heifer with the exception that it is usually necessary to separate the bulls and the heifers at about six months of age. From this time on it is advisable to feed the

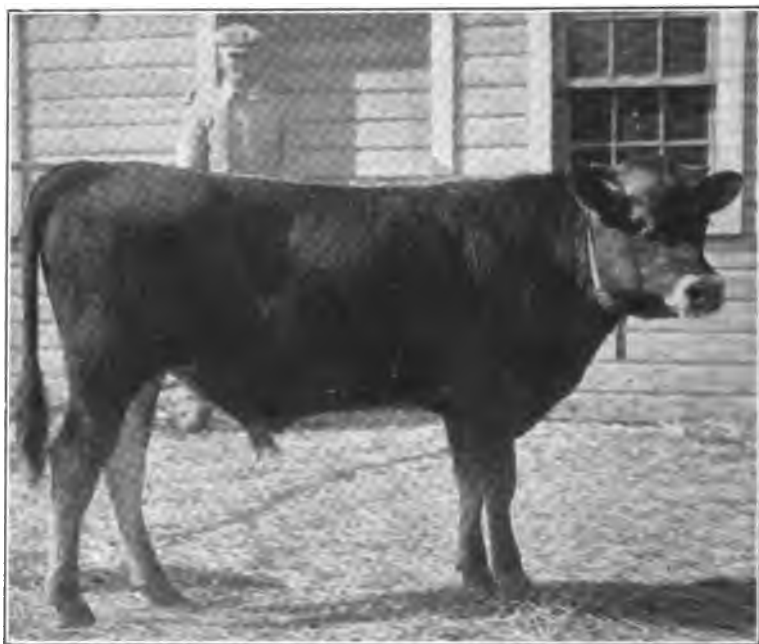


Fig. 8.—Pure-bred Jersey bull, nine months old. This bull is almost mature enough for very light service.

bull somewhat heavier than the heifer so as to induce the greatest possible growth. The same rations recommended for heifers, except in larger amounts, may be used to advantage.

The bull should be ready for very light service at the age of 10 to 12 months. However, his use at this time should be very limited, else his breeding powers may be permanently injured. It would probably be safe to allow him to serve one cow every three weeks up to the age of one year and not more than one cow per week up to the time he is 16 months old.

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SOY BEANS AND COWPEAS.

BY T. A. KIESSELBACH.

DISTRIBUTED APRIL 6, 1915.



A SHOCK OF SOY BEANS.

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L. L. ZOOK, B. Sc., *Assistant in Dry Land Agriculture, U. S. Department of Agriculture, North Platte.*

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FLORENCE A. MCCORMICK, Ph. D., *Assistant in Agricultural Botany.*

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SOY BEANS AND COWPEAS.

BY T. A. KIESSELBACH.

INTRODUCTION.

In recent years considerable interest has been manifest in Nebraska concerning soy beans and cowpeas; and numerous inquiries regarding them have come to the Experiment Station.

The cowpea is regarded as a profitable crop chiefly in the cotton States, but has some importance as far north as Missouri, Illinois, Indiana, and Ohio. On the other hand, the soy bean is adapted primarily to the Northern States between the regions best suited for cowpeas in the South and Canada field peas in the North. The Central States in which they are most commonly grown are Illinois, Indiana, Ohio, and Michigan, and they have been recommended for Kansas and Missouri. Much has been said of these crops in the States in which they are especially adapted, and the interest in them has spread to Nebraska.

Somewhat extensive experimental tests were made at the Nebraska Agricultural Experiment Station by Dr. T. L. Lyon, now of Cornell University. Included in these tests were nine varieties of soy beans for which yields were determined during the years 1903 and 1904.

In 1909 this Station secured seed of eight representative varieties of soy beans from Mr. C. V. Piper of the United States Department of Agriculture. At that time Professor E. G. Montgomery, now of Cornell University, again took up the testing of soy beans, which has been continued since 1911 by the writer, thus giving a continuous record of six years' work in recent years. Co-operative tests also have been made, during the past three years, with farmers of the State.

Tho our tests with cowpeas have not been extensive, this crop seems much less deserving of trial than soy beans.

HABITS OF GROWTH.

The soy bean is an upright, branching, annual legume varying in height, under normal conditions, from 1½ to 4 feet. It produces a small pod (very similar to the garden pea) which con-

tains from two to four seeds. The stem usually has five or six main branches, upon which are borne the leaves and clusters of seed pods. All the seed matures at practically the same time.



Fig. 1.—A typical soy bean plant.



Fig. 2.—A typical cowpea plant.

On the other hand, the cowpea has pods varying in length, from 5 to 15 inches, according to variety and seasonal conditions. Pods of varieties commonly grown in this State average about 6 inches in length. Under normal conditions the plants continue to bloom and set seed thruout the fall until frost. The most promising varieties suitable for growing in this State have a growth habit somewhat similar to that of the soy bean but are more prostrate and viny. The seeds of each crop differ greatly in size, shape, and color, according to variety. The flowers are usually self-fertilized, and it is not at all necessary for insects to carry the pollen. Figures 1 and 2 are typical soy bean and cowpea plants, respectively.

Being leguminous plants, they possess nodules with nitrogen-gathering bacteria on their roots just as do clover and alfalfa, when the proper bacteria are present in the soil.

Soy beans and cowpeas, in general, require nearly the same length of growing season as corn in eastern Nebraska, altho most varieties are somewhat later in maturing. Of the eight varieties of soy beans, which represent a wide variation in type, tested during the past six years, the earliest ripened September 16 on an average and the latest, October 10.

ADAPTATION AND USES FOR NEBRASKA CONDITIONS.

The uses to which these crops are put in various parts of the world are: (1) Food for man; (2) food for live stock, in the form of grain, hay, pasture, and silage; and (3) as soil restorers. In addition, soy bean oil is being used in the manufacture of paint, and for lubricants. The latter industry promises to develop more extensively.

Experience indicates that at the present time in Nebraska their chief value is as a protein concentrate and as hay for cattle, hogs, and sheep, and possibly for soil improvement. They deserve more extensive trial as food for man.

Indications are that cowpeas never will be a practical crop in this State. The yield of seed is relatively very low, and in forage production cowpeas are not superior to soy beans. The lack of sufficiently early varieties also limits the growing of cowpeas to eastern Nebraska.

Soy beans are the most practicable of any of the annual legumes. They are one of the most drouth resistant crops we have. However, more experience is required to grow a crop of soy beans successfully than is the case with our common field crops.

Varieties of soy beans are available that are sufficiently early to mature anywhere in Nebraska except in the northwestern por-

tion of the State. They may prove of considerable value in central and southwestern Nebraska where drouth resistance is a very important quality.

Several acres of soy beans must usually be planted where jack rabbits and grasshoppers are numerous in order to harvest a crop and make a satisfactory test, because these pests are very fond of soy beans, and frequently destroy smaller areas.

The soy bean has not proved to be a specially profitable crop, but will at least approach oats, acre for acre, in feeding value. Fifteen bushels of seed to the acre, or $1\frac{1}{2}$ tons of cured hay, is an average crop in eastern Nebraska under normal conditions. The yield will be somewhat lower farther west because of more limited rainfall. But on the other hand, the assurance of securing a stand is greater than with leguminous crops having small seeds, such as alfalfa or sweet clover. If the surface soil is too dry for germination, the seed may be planted 2 or 3 inches deep, thus reaching moist soil.

COMPOSITION AND FEEDING VALUE.

In composition and feeding value, the seed of the soy bean ranks very high and is much superior to that of the cowpea. It is a concentrated protein feed, being in this respect practically equal to oil meal. Its fat content is also very high. The soy bean seed contains 3.7 times as much digestible protein and 3.4 times as much digestible fat as corn, pound for pound.

Compared with the commonly used protein concentrate, oil meal, according to percentages given in Table 2, 1 ton, or 33 1-3 bushels, of soy beans contains 582 pounds of digestible protein. This is as much as is contained in 1,927 pounds of old process oil meal. A ton also contains 292 pounds of digestible fat, which is as much as is contained in 4,232 pounds of old process oil meal.

At this Station, during the six years 1909 to 1914, eight varieties of soy beans have averaged a yield of 14 bushels per acre. At this rate of production, the seed from an acre of soy beans contains as much digestible protein as 872 pounds of oil meal, and as much digestible fat as 1,777 pounds of oil meal.

The United States Department of Agriculture has estimated that, when used as a supplementary protein feed for live stock, "a bushel of soy beans is at least twice as valuable for feed as a bushel of corn." (See U. S. Farmers' Bulletin 372, p. 25.) Data are lacking to make an accurate comparative estimate of the feeding value of a carbohydrate concentrate, as corn, and a protein concentrate, as soy beans, under conditions where the protein may be supplied in such remarkably cheap forms as alfalfa,

TABLE 1.—*Relative composition of soy beans and cowpeas as compared with other feeds.*
(Data compiled from Henry's Feeds and Feeding.)

Feed	Water		Ash		Protein		Carbohydrates		
	Per cent	Per cent	Per cent	Per cent	Per cent	Per cent	Fiber	Nitrogen free extract	Fat
Soy beans (grain)	11.7	4.8	33.5	4.5	28.3	17.2			
Cowpeas (grain)	14.6	3.2	20.5	3.9	56.3	1.5			
Corn (grain)	10.6	1.5	10.3	2.2	70.4	5.0			
Oats (grain)	10.4	3.2	11.4	10.8	59.4	4.8			
Wheat grain	11.9	5.8	15.4	9.0	53.9	4.0			
Wheat bran	10.5	1.8	11.9	1.8	71.9	2.1			
Oil meal (old process)	9.8	5.5	33.9	7.3	35.7	7.8			
Oil meal (new process)	9.0	5.5	37.5	8.9	36.4	2.7			
Cottonseed meal (choice)	7.4	6.6	43.1	8.4	26.0	8.5			
Peanuts (kernels)	7.5	2.4	27.9	7.0	15.6	39.6			
Soy bean hay	11.8	7.0	14.9	24.2	37.8	4.3			
Cowpea hay	10.5	8.9	14.2	21.2	42.6	2.6			
Clover hay (red)	15.3	6.2	12.3	24.8	38.1	3.3			
Alfalfa hay	8.1	8.3	14.6	28.9	37.4	2.1			
Timothy hay	13.2	4.4	5.9	29.0	45.0	2.5			
Soy bean silage	74.2	2.8	4.1	9.7	6.9	2.2			
Cowpea silage	79.3	2.9	2.7	6.0	7.6	1.5			
Corn silage	73.6	2.1	2.7	7.8	12.9	0.9			

TABLE 2.—*Relative digestible nutrients and fertilizer elements in soy beans and cowpeas as compared with other feeds.*

(Data compiled from Henry's Feeds and Feeding.)

Feed	Digestible nutrients				Fertilizing elements		
	Protein	Carbo- hydrate	Fat	Nutritive ratio	Nitrogen	Phospho- ric acid	Potash
	Per cent	Per cent	Per cent	Per cent	Per cent	Per cent	Per cent
Soy beans (grain).....	29.1	23.3	14.6	1: 2.2	5.36	1.04	1.26
Cowpeas (grain).....	16.8	54.9	1.1	1: 3.4	3.28	1.01	1.20
Corn (grain).....	7.8	66.8	4.3	1: 9.8	1.65	0.71	0.57
Oats (grain).....	8.8	49.2	4.3	1: 6.6	1.82	0.78	0.48
Wheat grain.....	11.9	42.0	2.5	1: 4.0	2.46	2.69	1.52
Wheat bran.....	8.8	67.5	1.5	1: 8.0	1.90	0.87	0.55
Oil meal (old process).....	30.2	32.0	6.9	1: 1.5	5.42	1.66	1.37
Oil meal (new process).....	31.5	35.7	2.4	1: 1.2	6.00	1.74	1.34
Cottonseed meal (choice).....	35.8	23.2	8.0	1: 1.1	6.90	3.04	1.58
Peanuts (kernels).....	26.1	13.7	35.6	1: 3.7	4.46	1.24	1.27
Soy bean hay.....	10.6	40.9	1.2	1: 4.1	2.38	0.67*	1.08*
Cowpea hay.....	9.2	39.3	1.3	1: 4.5	1.43	0.52	1.47
Clover hay (red).....	7.1	37.8	1.8	1: 5.8	1.97	0.55	1.87
Alfalfa hay.....	10.5	40.5	0.9	1: 4.0	2.34	0.61	1.79
Timothy hay.....	2.8	42.4	1.3	1: 1.6	0.94	0.33	1.42
Soy bean silage.....	2.7	9.6	1.3	1: 4.6	0.66	0.16	0.75
Cowpea silage.....	1.5	8.6	0.9	1: 7.0	0.43	0.15	0.46
Corn silage.....	1.4	14.2	0.7	1:11.2	0.43	0.11	0.37

* From Ohio Agr. Exp. Station Bulletin 237.

clover, and sweet clover hay and pasture. In a feeding ration in which alfalfa or clover is fed liberally, there is little to be gained by feeding soy beans in addition. After a sufficient amount of protein has been supplied to balance the ration, any additional amount of protein fed replaces merely part of the carbohydrate. When protein serves merely to replace a carbohydrate, the actual feeding value pound for pound is slightly lower than that of the carbohydrate. Tables 1 and 2 have been compiled from Henry's *Feeds and Feeding*, 1913, to show the composition of soy beans and cowpeas as compared with other feeds. Henry is regarded as a standard authority on the composition of various feeds.

YIELDS IN OTHER STATES.

OHIO EXPERIMENT STATION.

During the three years 1909-1911, 10 varieties of soy beans gave an average yield of 23.62 bushels per acre, while the total weight of the crop harvested, including the entire plant, was 3,528 pounds. During the same period, three varieties of cowpeas produced an average yield of 5.83 bushels of seed, and 2,669 pounds total weight of crop, including the entire plant. The average farm production in Ohio is 18 bushels of soy beans per acre (Ohio Bul. 237). In Ohio Circular 132, 32 cooperative tests during 1912, indicating yields varying from 8 to 50 bushels per acre, are reported.

INDIANA EXPERIMENT STATION.

The average soy bean production at the Indiana Agricultural Experiment Station during the 12 years 1903-1913 was 18.8 bushels of seed per acre, while the yield of hay was 2.3 tons per acre. Cooperative tests by farmers during 1906-1912 in northern Indiana showed an average soy bean yield of 19 bushels of seed per acre. When cut for hay the yield was 1.5 tons. Cowpeas cut for seed yielded 12.5 bushels, and cut for hay the yield was 1.7 tons per acre. Similar cooperative soy bean seed and hay tests in southern Indiana yielded respectively 15.4 bushels of seed and 1.7 tons of hay per acre. (Ind. Bul. 172.)

KANSAS EXPERIMENT STATION.

Soy beans and cowpeas produced on an average during 1903-1908, 13.45 and 11.55 bushels of seed per acre respectively. When cut for hay, the yields were respectively 1.71 tons and 2.19 tons per acre. (Kans. Bul. 120.)

Soy Beans and Cowpeas.

ARKANSAS EXPERIMENT STATION.

During the years 1899-1901 cowpeas yielded 22.9 bushels of seed per acre. When cut for hay, the yield was 1.5 tons. (Ark. Bul. 70.)

KENTUCKY EXPERIMENT STATION.

The average yield of soy beans for three years, 1909-1911, in a rate planting test was 10.6 bushels. It is mentioned that these yields are much lower than should have been expected had more been known concerning the culture of this crop. Frequent reports are received at the Kentucky Agricultural Experiment Station from farmers who produced 20 to 30 bushels of soy beans per acre.

VARIETIES TESTED AT THE NEBRASKA EXPERIMENT STATION.

Nine varieties were tested in unduplicated plats, one-tenth acre in size, during each of two years, 1903 and 1904. The rows were 32 inches apart and cultivated. The results are given in Table 3.

TABLE 3.—*Average yield of nine varieties of soy beans tested at Nebraska Experiment Station, 1903-1904.*

Variety	Date planted	Date ripe	No. days required to mature	Yield of beans per acre (bushels)
Early Yellow	May 30	Sept. 20	112	15.10
American Coffee Berry	May 30	Sept. 20	112	12.72
Early Black.	May 30	Sept. 20	112	21.85
Ito San	May 30	Sept. 20	112	12.44
Wisconsin Black ...	May 30	Sept. 23	115	20.95
Medium Early Yellow.	May 30	Sept. 23	115	18.86
Medium Early Brown	May 30	Sept. 23	115	16.62
Medium Early Black	May 30	Sept. 23	115	11.95
Medium Green	May 30	Oct. 4	124	15.04
Average all varieties .....	.....	.....	.....	16.17

Further testing was discontinued until 1909 when eight varieties of soy beans representing a rather wide range of type were secured from Mr. C. V. Piper of the Bureau of Plant Industry, United States Department of Agriculture. These have been tested for six years, 1909-1914, and the data are given in detail for each year in Tables 4 to 9, in order that variation from year to

year may be observed. They are summarized in Tables 10 and 11. During the first three years, the beans were tested in single cultivated rows 42 inches apart, and duplicated three times, with a few exceptions as indicated in the tables.

During the last three years they have been grown in 4-row plats approximately one-fourteenth and one-seventeenth acre in size, according to space between rows. The entire series has been duplicated four times. They were tested in rows both 28 inches and 35 inches apart—the same amount of seed being sown per row regardless of the distance between rows. This makes the equivalent of two rates of planting—each rate being duplicated.

In the years 1909-1911 they were planted with a 1-row garden drill. In 1912 and 1913 a *Superior Grain Drill* was used with all feeds closed except those which would properly space the rows. In 1914 they were planted with an edge-drop corn planter.

Each year the seeder was so adjusted as to space the seed about 2 inches apart in the row. In rows 35 inches apart, this required approximately 30 pounds per acre with varieties having small seed and 40 pounds with varieties having larger seed.

In the variety and rate planting tests, the seed has been inoculated each year with artificial culture furnished by the United States Department of Agriculture.

The eight varieties from the Government included in these tests are as follows: Habaro, S. P. I. No. 20,405; Shingto, S. P. I. No. 21,079; Chernie, S. P. I. No. 18,227; Haberlandt, S. P. I. No. 17,271; Nuttall, S. P. I. No. 17,253; Cloud, S. P. I. No. 16,790; Amherst, S. P. I. No. 17,275; and Meyer, S. P. I. No. 17,582.

Cowpeas and an additional variety of soy beans, the Early Yellow, were tested in 1913 and 1914.

TABLE 4.—*Variety test of soy beans. 1909.*

Variety	Date planted	Date ripe	No. days required to mature	No. of duplications	Yield of beans per acre (bushels)
Habaro.....	June 3	Sept. 16	106	2	8.65
Shingto.....	June 3	Sept. 24	114	5	9.37
Chernie.....	June 3	Sept. 29	119	2	8.37
Haberlandt.....	June 3	Sept. 28	118	4	11.57
Nuttall.....	June 3	Sept. 29	119	4	7.12
Cloud.....	June 3	Oct. 5	125	4	12.40
Amherst.....	June 3	Oct. 14	134	4	14.40
Meyer.....	June 3	Oct. 14	134	4	10.32



1. 2. 3. 4. 5.



6. 7. 8. 9. 10. 11.

Fig. 3.—The varieties tested during 1909-1914. All but the Early Yellow soy bean and the cowpeas were tested six years. Reading from left to right, upper row: Cowpeas—1, New Era; 2, Whippoorwill. Soy Beans—3, Meyer; 4, Amherst; 5, Cloud. Lower row: 6, Nuttall; 7, Haberlandt; 8, Chernie; 9, Shingto; 10, Habaro; 11, Early Yellow.

TABLE 5.—*Variety test of soy beans. 1910.*

Variety	Date planted	Date ripe	No. days required to mature	No. of duplications	Yield of beans per acre (bushels)
Habaro.....	May 25	Sept. 17	115	3	20.3
Shingto.....	May 25	Sept. 23	121	3	20.0
Chernie.....	May 25	Sept. 24	122	3	20.1
Haberlandt.....	May 25	Sept. 29	127	3	19.7
Nuttall.....	May 25	Sept. 30	128	3	24.3
Cloud.....	May 25	Oct. 5	133	3	22.3
Amherst.....	May 25	Oct. 5	133	3	29.9
Meyer.....	May 25	Oct. 8	136	3	26.1

TABLE 6.—*Variety test of soy beans. 1911.*

Variety	Date planted	Date ripe	No. days required to mature	No. of duplications	Yield of beans per acre (bushels)
Habaro.....	May 25	Sept. 20	118	3	15.26
Shingto.....	May 25	Sept. 30	128	3	15.81
Chernie.....	May 25	Sept. 30	128	3	14.88
Haberlandt.....	May 25	Sept. 28	126	3	22.71
Nuttall.....	May 25	Sept. 30	128	3	22.14
Cloud.....	May 25	Oct. 6	134	3	18.79
Amherst.....	May 25	Oct. 7	135	3	21.96
Meyer.....	May 25	Oct. 7	135	3	21.03

TABLE 7.—*Variety test of soy beans. 1912.*

Variety	Date planted	Date ripe	No. days required to mature	No. of duplications	Yield of beans per acre. Average of 2 rates (bushels)
Habaro.....	May 21	Sept. 16	118	4	12.90
Shingto.....	May 21	Sept. 16	118	4	12.95
Chernie.....	May 21	Sept. 16	118	4	12.85
Haberlandt.....	May 21	Oct. 5	137	4	11.95
Nuttall.....	May 21	Oct. 5	137	4	9.39
Cloud.....	May 21	Oct. 5	137	4	8.69
Amherst.....	May 21	Oct. 5	137	4	8.93
Meyer.....	May 21	Oct. 5	137	4	9.70

TABLE 8.—*Variety test of soy beans. 1913.*

Variety	Date planted	Date ripe	No. days required to mature	No. of duplications	Yield of beans per acre. Average of 2 rates (bushels)
Habaro	June 2	Sept. 11	101	4	7.82
Shingto	June 2	Sept. 20	110	4	8.12
Chernie	June 2	Sept. 13	103	4	9.38
Haberlandt	June 2	Sept. 25	115	4	5.95
Nuttall	June 2	Sept. 29	119	4	6.04
Cloud	June 2	Oct. 11	131	4	3.85
Amherst	June 2	Oct. 11	131	4	2.63
Meyer	June 2	Oct. 11	131	4	5.09
Early Yellow	June 2	Sept. 7	96	4	6.60

Cowpeas.

New Era	June 2	Sept. 14	104	4	2.00
Whippoorwill*	June 2	.....	.....	4	0

*The Whippoorwill variety set practically no seed pods.

TABLE 9.—*Variety test of soy beans. 1914.*

Variety	Date planted	Date ripe	No. days required to mature	No. of duplications	Yield of beans per acre. Average of 2 rates (bushels)
Habaro	May 20	Sept. 15	118	4	16.78
Shingto	May 20	Sept. 28	131	4	15.78
Chernie	May 20	Sept. 28	131	4	16.54
Haberlandt	May 20	Oct. 5	138	4	21.49
Nuttall	May 20	Oct. 5	138	4	16.29
Cloud	May 20	Oct. 10	143	4	14.29
Amherst	May 20	Oct. 10	143	4	17.39
Meyer	May 20	Oct. 17	150	4	16.24
Early Yellow	May 20	Sept. 12	115	4	15.70

Cowpeas.

New Era	May 20	Sept. 15	118	4	4.6
Whippoorwill*	May 20	.....	.....	4	0

*The Whippoorwill cowpeas produced no seed pods.

TABLE 10.—*Showing six years' average performance of eight soy bean varieties. 1909-1914.*

Variety	Average date planted	Average date ripe	Average no. days required to mature	Total no. plats averaged	Yield of beans per acre (bushels)
Habaro	May 25	Sept. 16	114	20	13.62
Shingto	May 25	Sept. 23	121	23	13.67
Chernie.....	May 25	Sept. 23	121	20	13.69
Haberlandt	May 25	Sept. 30	128	22	15.56
Nuttall	May 25	Oct. 1	129	22	14.21
Cloud	May 25	Oct. 7	135	22	13.39
Amherst	May 25	Oct. 9	137	22	15.87
Meyer	May 25	Oct. 10	138	22	14.75

TABLE 11.—*Summary of variety tests with soy beans for six years. 1909-1914.*

Variety	Air-dry yield per acre—bushels.						
	1909	1910	1911	1912	1913	1914	6-year average
	<i>Bus.</i>	<i>Bus.</i>	<i>Bus.</i>	<i>Bus.</i>	<i>Bus.</i>	<i>Bus.</i>	<i>Bus.</i>
Habaro	8.65	20.30	15.26	12.90	7.82	16.78	13.62
Shingto	9.37	20.00	15.81	12.95	8.12	15.78	13.67
Chernie	8.37	20.10	14.88	12.85	9.38	16.54	13.69
Haberlandt	11.57	19.70	22.71	11.95	5.95	21.49	15.56
Nuttall	7.12	24.30	22.14	9.39	6.04	16.29	14.21
Cloud	12.40	22.30	18.79	8.69	3.85	14.29	13.39
Amherst	14.40	29.90	21.96	8.93	2.62	17.39	15.87
Meyer	10.32	26.10	21.03	9.70	5.09	16.24	14.75
Average	10.28	22.84	19.07	10.92	6.11	16.85	14.35

SOY BEANS AND COWPEAS FOR HAY.

In 1912 and 1913 both soy beans and cowpeas were drilled in rows 8 inches apart, for hay and seed. Under these conditions the crop could not be cultivated and was overcome by weeds each year. This has not proved a practical way for planting in eastern Nebraska, altho it might prove satisfactory in the western part of the State where weeds are not so troublesome because of lower rainfall. Several duplicate plats were planted in 1912 and 1914 in rows 28 inches apart which were cultivated and harvested for hay, the results from which are given in Table 12. Judging from the general appearance of the plant, the Cloud variety would make a better quality of hay than the other varieties tested.

TABLE 12.—*Summary of hay yields in 1912 and 1914.*

Year	Crop	Yield of cured hay per acre	Yield of cured hay per acre
		<i>Pounds</i>	<i>Tons</i>
1912	Whippoorwill cowpeas	2,729	1.37
	Amherst soy beans.....	2,856	1.43
1914	Whippoorwill cowpeas	2,900	1.45

6.

The hay from either of these crops when properly cured makes excellent forage for cattle, hogs, and sheep. Its feeding value is practically equal to alfalfa and clover. Being less productive, however, and more difficult to grow where cultivation is necessary to keep down weeds, they are not so profitable as either alfalfa or clover in those parts of the State where the latter two thrive.

Three tons of alfalfa hay per acre were produced at the Nebraska Agricultural Experiment Station in those years when soy beans and cowpeas yielded not quite 1½ tons of hay. In this comparison the alfalfa field was several years old, and the soy beans and cowpeas were planted in cultivated rows 28 inches apart.

Because of their forage value these crops need seldom be considered a total failure. Their hay value is very important when too late a variety is planted to mature satisfactorily, or if for any other reason the seed yield promises to be very small, as the field may then be harvested for hay.

SOY BEANS AND COWPEAS FOR SILAGE.

In some States both soy beans and cowpeas are recommended for silage as a mixture with corn. Used alone they are not suitable for silage. They may be planted: (1) As a mixture in the same row with corn; (2) in rows between widely spaced corn rows as is common in the South; or (3) the beans or peas and the corn may be grown in separate fields and mixed as they are placed in the silo.

At the Nebraska Agricultural Experiment Station, corn yields on an average about 8 tons of silage per acre. Those varieties of soy beans and cowpeas making the maximum amount of vegetative growth yield at the rate of about 6 tons of silage, or three-fourths as much as corn. As a general farm practice we consider it far more practicable in this State to make silage of corn alone and to grow alfalfa hay for the protein needed to balance the ration.

In 1914 soy beans of the Cloud variety were planted in the rows of corn for mixed silage. The results follow:

TABLE 13.—Yields of soy beans and corn planted together for silage. 1914.

Crop	Yield per acre of green silage	Per cent water when harvested September 5	Yield per acre moisture free substance
	<i>Tons</i>	<i>Per cent</i>	<i>Tons</i>
Corn alone.....	9.98	75.4	2.45
Corn and soy beans mixed....	9.84	74.7	2.49

We were unsuccessful in securing a satisfactory distribution by mixing the corn and beans in the planter box. The beans tend to work to the bottom and feed out faster than the corn. In the above trial, the corn was drilled 14 inches apart in the row, and the rows were then gone over again with the planter, drilling the beans about 6 inches apart.

Some farmers have reported growing cowpeas and corn together in the row for silage and found difficulty in harvesting the beans properly with the corn harvester. This method of culture is not recommended.

RELATIVE YIELDS OF SOY BEANS AND PRINCIPAL GRAIN CROPS AT NEBRASKA EXPERIMENT STATION.

Moisture conditions at the Experiment Station have been comparatively unfavorable for corn and soy beans during the past six years in which these comparisons are made. This is shown by the fact that corn has produced 25 bushels per acre less at the Station during the past six years than during the previous seven years. Since soy beans occupy the same part of the growing season as corn, the yield from them may be assumed to have been reduced in somewhat the same manner. Wheat and oats have yielded practically the same during the last six years as during the preceding seven.

In Table 14 the grain yields are reported from our standard, best adapted varieties. Since the Haberlandt variety of soy beans seems best adapted to conditions at the Experiment Station, the yield of this variety makes a better comparison with the other grains than does the average yield from the eight varieties. In Table 15 these crop yields are calculated in terms of available nutrients.

TABLE 14.—*Summary showing comparative yields of corn, wheat, oats, and soy beans at Nebraska Experiment Station for the last six years. 1909-1914.*

Crop	Yield per acre						Average for 6 years	
	1909	1910	1911	1912	1913	1914		
	Bus.	Bus.	Bus.	Bus.	Bus.	Bus.	Bus.	Lbs.
Hogue's Yellow Dent corn.....	41	58	43	48	8	53	42	2,352
Turkey Red wheat...	27	48	51	9	50	34	36.5	2,160
Kherson oats.....	67	42	38	37	45	68	49.5	1,568
Average of 8 soy bean varieties.....	9	23	19	11	6	17	14	840
Haberlandt soy beans	11.5	20	23	12	6	21.5	16	960

SOY BEANS AND COWPEAS AS SOIL IMPROVERS.

For the purpose of increasing the soil fertility, either of these crops is much inferior to clover or alfalfa. On very poor soil it may pay to plow under an entire crop. In this way an amount of nitrogen will be added to the soil equivalent to that of an equal quantity of clover. According to Dr. Cyril G. Hopkins of the Illinois Agricultural Experiment Station (in *Soil Fertility and Permanent Agriculture*) the stubble and roots of a ton of air-dry soy bean forage contain only about 6 pounds of nitrogen while the stubble and roots of a ton of air-dry clover hay contain 20 pounds of nitrogen. Accordingly an average yield of red clover cut for hay in eastern Nebraska will leave four times as much nitrogen in its roots and stubble as an acre of soy beans cut for seed. Clover has probably about the same superiority over cowpeas.

It has sometimes been suggested that these crops be used as green manure crops to be planted in the stubble after the wheat or oats harvest and plowed under late in the fall. It has been our experience that, in Nebraska, success with this practice is very uncertain because of limited rainfall. Only a small total growth is made so late in the year, and the increased fertility would usually scarcely repay the cost of seed and labor. Furthermore, to grow such a catch crop for green manuring uses soil moisture at the expense of the following year's crop, as much of this moisture might otherwise be stored in the soil for the next crop. In Nebraska where moisture is often the limiting factor in crop production, the situation is different from that in the more humid States to the east and southeast, where catch crops are profitably used in this manner.

TABLE 15.—*Showing average yield of digestible nutrients of corn, wheat, oats, and soy beans at Nebraska Experiment Station during the six years—1909-1914.*

Crop	Yield grain per acre, average 6 years	Digestible nutrients				Total starch equivalent of starch and fat †
		Protein	Carbo- hydrates	Fat	Starch equivalent of fat*	
	<i>Pounds</i>	<i>Pounds</i>	<i>Pounds</i>	<i>Pounds</i>	<i>Pounds</i>	<i>Pounds</i>
Hogue's Yellow Dent corn	2,352	183.4	1,571.1	101.1	227.5	1,798.6
Turkey Red wheat	2,190	192.7	1,478.2	32.8	73.8	1,552.0
Kherson oats	1,584	139.3	779.3	68.1	153.2	932.5
Haberlandt soy beans.	960	279.3	223.6	140.1	315.2	538.8
Average of 8 soy bean varieties . . .	840	244.4	195.7	122.6	275.8	471.5

* This column is obtained by multiplying the amount of fat by 2.25. One pound of fat is equal in feeding value to 2.25 pounds of starch.

† This column is obtained by adding to the actual amount of starch the amount of starch which is equal to the fat in feeding value.

PLACE IN THE ROTATION.

In portions of the State where the earlier varieties mature in time, soy beans and cowpeas may sometimes be followed to good advantage with winter wheat. These crops leave the ground in such a loose and open condition that a satisfactory seed bed for wheat can often be secured by simply disking rather than by plowing the land. It is probable, however, that in ordinary farm practice it may not always be possible to clear the land in time for wheat, as abnormal conditions may cause the crop to ripen late or rains may delay removing it from the land. Any spring planted farm crop may successfully follow these legumes. Under Nebraska conditions either soy beans or cowpeas should be grown only with the expectation that they will consume the entire season. It will, therefore, be necessary to grow them in place of, rather than in addition to, some other crop in any one season.

VARIETIES AND SEED.

For southeastern Nebraska we consider the Haberlandt variety best. For the northern, central, and western portions of the State, the Habaro, Chernie, Shingto, and Early Yellow are most suitable. It is probable that of these early varieties Early Yellow (Ito San) is the only one commercially available. Seed houses may not handle the Haberlandt variety, in which case the Medium Yellow may be used as a substitute. This is a medium early commercial variety but a trifle late for all except the southeastern counties in this State. There would doubtless be an opportunity for a few farmers in the State to grow seed of well-adapted varieties to supply the home trade. Seed usually sells for from \$2.50 to \$3.50 per bushel.

Of the cowpea varieties, the New Era seems to be one of the most practical to grow in this State.

Seed of both soy beans and cowpeas usually deteriorates in germinative power when more than one or two years old.

INOCULATION.

Soy beans and cowpeas, being leguminous plants, are more productive when nodules develop upon the roots and are less draining upon the nitrogen content of the soil. These nodules are merely the home of innumerable nitrogen-gathering bacteria or germs, which take this element directly from the air. These nodule-forming bacteria are found on no field crop plants except those belonging to the legume family. The soy bean possesses its own particular kind of bacteria and cannot be inoculated with

germs from any other species. On the other hand, soy bean bacteria will inoculate no other plant. The cowpea likewise possesses its own peculiar bacteria.

In soils where nodules fail to develop, inoculation may be secured by scattering 300 or 400 pounds of soil per acre from some field upon which the same crop has previously been grown. Since strong sunlight is injurious to the bacteria, this soil should be scattered on a cool, cloudy day and be harrowed in immediately.

A common, but more uncertain, method of inoculation is to apply to the seed a prepared culture made for the particular crop. Inoculating cultures may usually be secured free of charge from the United States Department of Agriculture, Washington, D. C., upon request, by agreeing to leave a portion of the field untreated and reporting results. Cultures may also be purchased from manufacturers and seed dealers. Methods for inoculating these crops are the same as have often been described for alfalfa.

Unless the soil is known by experience to contain the necessary bacteria, it is a wise plan to inoculate before seeding. A number of farmers in the State have reported beneficial effects from inoculating the seed, altho the majority have observed no benefit. The soils at the Nebraska Agricultural Experiment Station appear to possess the soy bean bacteria, as inoculation by both the culture and the soil method failed to increase the yield materially, as is shown in the following table:

TABLE 16.—*Effect of inoculating soy beans.*

Year	Crop	Size of plat	No. of duplica-tions	Yield per acre		
				Soil inocula-ted	Culture inocula-ted	No inocula-tion
1912	Amherst soy beans.	<i>Acre</i> 1-6	2	<i>Bus.</i> 15.7	<i>Bus.</i> 16.4	<i>Bus.</i> 15.9
1913	Amherst soy beans.	1-10	2	3.8	4.5	3.1
Average for 2 years.				9.8	10.4	9.5

TIME, RATE, AND MANNER OF PLANTING.

Soy beans and cowpeas should be planted immediately after corn planting time. Varying somewhat in different years according to seasonal conditions, May 15 to May 30 may be considered as the best range of planting dates for Nebraska. Earlier planting will usually not hasten maturity, and may result in a poor stand. It is important that the ground be thoroly warm at planting time.

The seed bed should be prepared the same as for corn. Our experience at the Experiment Station has been only with plowing and surface planting. This is the method also commonly employed in other States. There are a few advocates of listing. In western Nebraska listing is probably a good practice, but the method has not been sufficiently tried for general recommendation.

During the last three years of the variety test at this Station, 1912-1914, each variety was planted in plats with rows 28 and 35 inches apart. With both spacings, the seeds were dropped ap-



Fig. 4.—A typical field of soy beans planted in rows 35 inches apart and cultivated.

proximately 2 inches apart in the row. This required about 40 pounds of seed per acre with the large seeded varieties and 30 pounds with the small seeded varieties in rows 35 inches apart. During the three years, the average yield of the four earliest varieties, with September 23 as an average ripening date, was 1 bushel more per acre when the rows were 28 inches apart; while the four latest maturing varieties, ripening on an average October 7, yielded 1 bushel less when the rows were 28 inches apart. The later varieties made the largest vegetative growth and fully occupied the ground at the thinner rate of planting, while this was

not true of the smaller, earlier varieties. The results of this test are given in Table 17.

TABLE 17.—*Showing the effect of distance between rows and rate of planting soy beans.*

Variety	1912		1913		1914		Average	
	Distance between rows							
	35 in.	28 in.	35 in.	28 in.	35 in.	28 in.	35 in.	28 in.
	<i>Bus.</i>	<i>Bus.</i>	<i>Bus.</i>	<i>Bus.</i>	<i>Bus.</i>	<i>Bus.</i>	<i>Bus.</i>	<i>Bus.</i>
Habaro	12.30	13.50	7.25	8.39	15.72	17.85	11.76	13.25
Shingto	13.50	12.40	7.58	8.66	14.42	17.12	11.83	12.73
Chernie	14.25	11.25	7.67	10.23	14.25	18.84	12.06	13.44
Haberlandt	11.45	12.45	5.54	6.37	21.82	21.15	12.94	13.32
Nuttall	10.15	8.60	5.98	6.11	18.42	14.17	11.52	9.63
Cloud	7.90	9.45	3.30	4.00	15.83	12.75	9.01	8.73
Amherst.	10.05	7.80	2.81	2.43	17.18	17.61	10.01	9.28
Meyer	11.00	8.40	5.70	4.48	16.15	16.32	10.95	9.73
Average all varieties.	11.33	10.48	5.73	6.33	16.72	16.98	11.26	11.26

Experience at other Agricultural Experiment Stations leads us to believe that cowpeas should be planted somewhat thinner than soy beans in rows 35 inches apart.

An ordinary grain drill, with part of the feeds closed to give proper width between the rows, is the best machine for planting. Of the different types of force feed in drills, one kind has a disk such that in forcing out the seed for various rates of planting it revolves at different speeds. This type does not crack the seed much and does good work. The oats side of the drill should be used and set between 9 and 12 pecks per acre, according to size of seed. The drill may be easily adjusted if this does not give the proper spacing. A corn planter fitted with bean plates may also be used quite successfully. Plates regularly accompanying corn planters can usually be adjusted or altered so as to space the seed properly. The machine to be used should be tested and adjusted in advance so as to space the seed between 2 and 3 inches apart. The rows should not be closer than 28 inches because of increasing the difficulty of cultivation.

Where seed is drilled from every drill spout in rows 7 inches apart for forage or green manuring, 6 pecks per acre should be used. It must be remembered that weeds are likely to become bad in uncultivated fields.

CULTIVATION.

It is recommended that the field be disked and harrowed just prior to seeding in order to check the weed growth as much as possible. A weeder may be run over the ground just before the beans come up and again before the beans are large enough to cultivate. The weeder should be used only during the warmer portion of the day, as the plants are inclined to be brittle and break in the morning. Three or four cultivations are required. It has been our experience that ordinarily at least one hoeing along the



Fig. 5.—Cowpeas ready to harvest.

row when the plants are small will be necessary. One man can hoe about an acre a day.

The labor connected with growing the crop makes it a rather poor substitute for oats so far as the management of farm labor is concerned. If soy beans were grown extensively, the acreage of corn would necessarily be reduced, since both require cultivation at the same time.

HARVESTING.

Soy beans and cowpeas may be harvested with a mower or a specially made bean harvester. We have also found it practicable to harvest soy beans for seed with a binder. Some varieties are

too short and others too viny to harvest in this manner. In case a mower is used, it is well to have a side delivery attachment in order that the horses will not need to tramp on the cut swath of beans. This tramping is likely to shatter many of the beans.

In general, the proper stage to cut soy beans for seed is when the pods have turned brown or blackish according to variety, and about two-thirds of the leaves have fallen. During this stage of development, they require close attention, because if cutting is delayed, considerable loss of seed will be sustained from shatter-



Fig. 6.—Soy beans ready to harvest for seed.

ing. This is especially true in case of frost. If the beans are permitted to stand until thoroly ripe, much loss of seed may be expected from this source. Inexperienced growers are likely to suffer serious loss from shattering of the seed thru improper handling.

After curing in the windrow for a day or two, the beans should be placed in shocks. When thoroly cured it is best to thresh them immediately. In case this cannot be done, they should be stacked to avoid unnecessary exposure and consequent shattering in the shock. Soy beans, when stacked, should be covered with canvas or coarse hay to exclude rain.

Cowpeas differ greatly from soy beans in their manner of ripening seed. Under normal conditions they continue to bloom and set pods thruout the fall until frost. As a grain crop, they should be harvested when, in the judgment of the grower, the maximum amount of seed is ripe.

For hay the crop should be harvested when the pods are well formed. At this stage most of the leaves are still on, and the stems have not become coarse and woody. After curing in the swath a day or two, they may be raked and cocked. Cowpeas dry more slowly than soy beans. It may take a week or 10 days of good drying weather before either crop can be stacked. This is a serious handicap.

THRESHING AND STORING.

These crops may be threshed with an ordinary threshing machine by reducing the speed of the cylinder and replacing all or part of the concaves by blank concaves. The best adjustment of the thresher is by the use of special pulleys which reduce the speed of the cylinder without reducing that of the rest of the working parts of the machine. Many of the seeds are likely to be broken in threshing, but this does not reduce their feeding value.

The beans or peas should be watched carefully after threshing to avoid heating and molding. When thoroly dry, there is no such danger. Unless very dry it may be necessary to spread them out rather thin for a time.

FARMERS' TESTS WITH SOY BEANS.

During the years 1912, 1913, and 1914 the Experiment Station supplied a number of farmers with soy bean seed, together with suggestions relative to planting, cultivating, and harvesting the crop. In all cases the soy beans were planted in rows and cultivated. The farmers either were supplied with both inoculated and uninoculated seed for comparison, or were furnished inoculating culture from the United States Department of Agriculture.

TESTS IN 1912.

In 1912 three farmers in southeastern Nebraska tested Amherst soy beans for seed with rather encouraging results. Their yields were respectively 18, 20, and 20 bushels per acre. From two to three acres were grown by each man.

TESTS IN 1913.

Ten reports were received from farmers growing soy beans in 1913. The area planted varied from $\frac{1}{2}$ to 6 acres. Only three

men harvested their crop for seed, with yields of 6, 8, and 15 bushels, respectively. Owing to the extreme drouth, and in some instances to inexperience either in planting or harvesting, the others did not thresh their crop. The beans were pastured in two cases with satisfactory results. Two cooperators cut their crop for hay, which yielded at the rate of $1\frac{1}{2}$ tons per acre, and reported that the stock to which it was fed—milch cows and sheep—liked it fully as well as choice alfalfa hay. It should be noted that in these cases the crops were not promising for seed on account either of drouth or danger from frost.

Six of these farmers found it necessary to hoe the soy beans at least once. Cultivation proved more difficult and weeds harder to subdue than in the case of corn planted with a planter. There was no noticeable superiority in development due to the use of inoculation culture in eight of these ten tests.

Four of these farmers intended planting soy beans again the following year, and only one reported having seed for sale. Opinion as to the utility of this crop was quite evenly divided, but in a comparative way the soy bean was ranked as inferior to our standard crops in nearly all cases.

TESTS IN 1914.

Nineteen farmers reported results of their trials with soy beans. The areas planted were in most cases from 1 to 3 acres in extent, and the yield was from 3 to 30 bushels per acre. The data may be summarized as in the following table:

TABLE 18.—*Farmers' tests with soy beans. 1914.**

Question	No. of replies yes	No. of replies no	Doubtful
Were they harder to cultivate than corn?	10	1	1
Was it harder to keep weeds down?	10	1	....
Do they need hoeing?	9	1	1
Are they a practical crop?	1	6	3
Will you grow them again?	4	6	1
Did inoculation prove favorable?	2	6	1
Does this crop mature?	3	1	3
Have you seed to sell?	1	8	.....
Does yield compare favorably with other crops? . .	2	6	2
Do they ripen in time to follow with winter wheat?	2	2	2

* The average yield of seven farmers reporting the yield was 14 bushels per acre.

The relatively small number of replies to the questions as shown in the table is due either to the fact that many of the co-operators replied only to a part of the questions asked, or their crops were discarded owing to poor stands or damage.

Besides finding this crop harder to handle than most of our field crops, and less profitable, mention was made of damage resulting from jack rabbits, drouth, hail, wind, rain, frost, and shattering.

In considering the reports for 1913 it must be borne in mind that that season was an unusually dry one in southeastern Nebraska, where most of these trials were made, and that for this reason less trouble was caused by the growth of weeds than would be the case in years of average rainfall.

Taken as a whole, these reports from our co-operators are unfavorable to soy beans as a general purpose crop in Nebraska, but we should not underestimate the fact that inexperience in growing this crop is an important adverse factor.

SUMMARY.

1. The climatic adaptation of soy beans to Nebraska conditions as a whole is much better than that of cowpeas. Varieties may be had which will mature before frost in all parts of the State, except perhaps in the northwest. On the other hand, cowpeas should, at least for the present, be confined to the southern and southeastern portions of this State.

2. Soy beans do not show the effects of drouth as quickly as corn, and reductions in yield due to drouth are relatively less marked. However, soy beans are by no means entirely drouth resistant, and the amount and distribution of rainfall are important controlling factors.

3. Neither soy beans nor cowpeas are grown extensively in Nebraska. They have been tried in an experimental way for 15 years, but have nowhere come into common use.

4. In those States where these crops have come into favor with farmers, they are used for grain, hay, silage, pasture, and soil improvement. In Nebraska their chief value is, doubtless, as a grain crop to provide a protein concentrate for live stock. The low grain yields of cowpeas make them impractical, therefore, in this State. Soy beans merit more extensive trial as human food.

5. Under Nebraska conditions, alfalfa and red clover yield more forage with lower labor cost and are much more effective in soil improvement than are cowpeas or soy beans. It must be remembered, however, that, excepting in valleys and otherwise

avored locations, red clover is satisfactory only in the eastern third, and alfalfa only in the eastern two-thirds, of the State.

6. Ordinarily, cowpeas and soy beans should be planted in rows from 30 to 35 inches apart with the seed spaced from 2 to 3 inches in the row. Planted in this manner, at least three cultivations and usually one hoeing are necessary to keep down the weeds.

7. The average yield of soy beans during eight years at the Nebraska Agricultural Experiment Station has been 14.8 bushels per acre. In feeding value per acre this is less than was obtained from oats, and the cost of production was higher.

8. Since soy bean grain must be used for feed in the same manner as oil meal and is equal in value as a concentrate, the cost of the oil meal may be used as a standard to measure the acre value of soy beans. It must be remembered, however, that the protein needed to accompany corn and balance the ration can usually be much more cheaply supplied in the form of alfalfa hay and alfalfa pasture, the latter being especially good for hogs.

9. Since soy beans require cultivation in a manner similar to corn and at about the same time, they should be compared with corn in point of practical utility. The soy bean is one of those crops which look promising and inviting but which nevertheless are not quite sufficiently meritorious to take a place among our standard crops under existing conditions.

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CORN SILAGE AND ALFALFA HAY FOR BEEF
PRODUCTION.

BY R. K. BLISS AND C. B. LEE.

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SUMMARY.

1. A ration of corn and alfalfa hay produced the cheapest gains of any ration used. Furthermore, the steers fed corn and alfalfa hay made as rapid gains as did the steers on any other ration.

2. Had the alfalfa hay used in the first experiment cost \$20 per ton, the average profit on the three lots receiving alfalfa would have been 15 per cent greater than the profit on the best one of the three lots not receiving alfalfa.

3. Cold pressed cottonseed cake did not give as good results, as regards either rate of gain or economy of gain, as did alfalfa hay in a ration for fattening steers.

4. The addition of cold pressed cottonseed cake to a ration of corn, silage, and alfalfa increased the cost of gain and lowered the profits on the steers.

5. The steers receiving silage without exception shed their coats early in the spring and at all times presented a sleek and sappy appearance.

6. Contrary to preceding experiments, a heavy feed of silage with alfalfa hay and corn gave as rapid gains as did either a medium or a light feed of silage with alfalfa hay and corn. The amount of silage which can best be fed to fattening steers apparently must be regarded as unsettled.

7. The steers fed silage in connection with corn and alfalfa suffered a very light shrinkage when shipped to market. Different amounts of silage seemingly had no effect upon the number of pounds shrinkage.

8. Where prairie hay was used in place of alfalfa, small and expensive gains resulted.

9. The individuality of a steer is a very important factor in the rate of gain. The average difference in gains made between the highest and lowest producing steer in each of fourteen different lots was 120 pounds. In practically all cases there was a greater variation in the daily gains made by steers in the same lot than there was in the average daily gains of the different lots.

10. Usually a considerable difference can be noted between poor and good feeder cattle, but sometimes even a careful study of steers does not reveal their feeding possibilities.

11. An advance of 8 cents per bushel in the price of corn increased the cost of gains \$1 per 100 pounds.

12. In the second experiment, where a ration of corn and alfalfa hay was fed, an increase of 1 cent per bushel in the price of corn had the same effect in increasing the cost of gains as did an increase of \$1 per ton in the price of alfalfa hay.

CORN SILAGE AND ALFALFA HAY FOR BEEF PRODUCTION.

BY R. K. BLISS AND C. B. LEE.

INTRODUCTION.

In previous bulletins attention has been repeatedly called to the value of alfalfa hay in the steer ration. The many tests which have been conducted by the Nebraska Experiment Station, in which alfalfa hay was compared with various other food materials as a supplement to grain in a ration for fattening steers, have produced convincing evidence in regard to the superior qualities of alfalfa. Among the grains, corn has long been considered preeminent as a fattening food. But corn, while a rapid fat producer, does not supply the protein and mineral materials demanded by the animal body. Consequently, when corn is used in a ration, some other feed must be supplied to furnish these materials. Alfalfa contains abundant protein and minerals. It thus corrects the deficiencies of corn. Since the Nebraska cattle feeder is in a position to secure both corn and alfalfa at a small cost, under normal conditions the most economical ration for Nebraska beef producers is one composed of alfalfa and some part or parts of the corn plant. Whether or not the cornstalks can be included in the "most economical" beef producing ration and in what form and quantity they can be fed in order to yield the greatest profit are problems which remain to be definitely settled, and may differ in different localities or in different years.

The economy of silage in the ration of the dairy cow has been proved by many experiments in recent years. In the fattening of steers there are much fewer experimental data, some of which seem to be conflicting. The two experiments recorded in the present bulletin were inaugurated largely for the purpose of securing information on this subject. The first experiment was carried on during the winter of 1912-13, and the second experiment was carried on during the winter of 1913-14.

EXPERIMENT 1.**PLAN.**

For carrying on this test 48 head of two-year-old steers were purchased on the South Omaha market November 1, 1912. These steers classed as "fair feeders" and consisted of grades of the Shorthorn and Hereford breeds, bred and raised in the range country of western Nebraska.

As soon as they arrived at the Experiment Station, the steers were fed alfalfa hay. After being in the yards about a week, a light feed of corn was given in addition to the alfalfa. The corn allowance was gradually increased until each steer was receiving about 9 pounds per day on December 17, when the steers were divided into 6 lots and started on the experimental rations. Great care was taken in selecting the steers for the different lots, in order that the lots would be just as similar as possible in regard to weight and quality.

Shortly after the experiment began, one steer in Lot 6 was taken out of the experiment because of his extremely nervous disposition. Later on, one of the steers in Lot 5 went "off feed" so completely that he also had to be dropped from the test. This left 8 steers in each of Lots 1, 2, 3, and 4, and 7 steers in each of Lots 5 and 6.

The feeding was done in a barn equipped with stanchions, so that each steer could be fed individually. By this method of feeding an opportunity was given for a critical study of the individual animals. The steers were fed at 7 a. m. and 5 p. m. In the daytime they were turned into open yards for exercise. Water and salt were provided in the yards, so that the steers had free access to both at all times. It should be kept clearly in mind that the object of feeding inside in stanchions was in order to study the variation in individual steers in making gains. The Nebraska Experiment Station is fully convinced that the most economical method of feeding two-year-old cattle in eastern Nebraska, so far as shelter is concerned, is to feed in the open with a windbreak or shed on the north, east, and west. It would be impossible, however, to feed outside and at the same time keep individual records.

Individual weights were taken on three consecutive days at the beginning and close of the experiment and at 28-day periods intervening. The experiment closed on May 22, 1913, at which time the steers had been on feed 157 days.

RATIONS USED.

The following rations were fed the different lots:

Lot 1.—Ground corn, cold pressed cottonseed cake, and prairie hay.

Lot 2.—Ground corn, corn silage, and cold pressed cottonseed cake.

Lot 3.—Ground corn, corn silage, and prairie hay.

Lot 4.—Ground corn, a heavy feed of corn silage, and alfalfa hay.

Lot 5.—Ground corn, a medium feed of corn silage, and alfalfa hay.

Lot 6.—Corn and alfalfa hay.

In addition to the feeds mentioned, each steer in the test received 1 pound of oat straw per day. The straw was fed in order to furnish more variety in the rations.

When the experiment started, each steer in Lot 4 was receiving 30 pounds of silage per day, while each steer in Lot 5 was receiving 20 pounds of silage per day. After being on feed 8 weeks the daily silage allowance for both lots was reduced 5 pounds per steer. The steers in Lot 2 were given all of the silage that they would eat. The average amount eaten by each steer in the lot thruout the experiment was 28.6 pounds per day. Lot 3 was fed the same amount of silage as Lot 5. All of the lots received an equal amount of corn, the grain contained in the silage being taken into consideration in adjusting the corn rations.

Ground corn was fed because it was practically impossible to allow hogs to follow stanchion fed cattle. The Nebraska Experiment Station believes that the most economical method of feeding corn to cattle is to feed it in the ear or shelled, and provide sufficient hogs to clean up all droppings thoroly. Where hogs in sufficient numbers to pick up the corn cannot be had because either of scarcity or danger of disease, it pays to grind the corn. The plan of studying individual steers made it necessary to eliminate the hogs and grind the corn.

PRICES OF FEEDS.

The feeds used were valued as nearly as possible at prices prevailing on Nebraska farms at the time the experiment was in progress. Since these prices fluctuate widely from time to time, the financial returns are of importance only for matters of comparison. The feed valuations follow:

Ground corn, per bushel	\$0.42
Cold pressed cottonseed cake, per ton.....	24.00
Alfalfa hay, per ton	8.00
Prairie hay, per ton	7.00
Corn silage, per ton	3.00
Oat straw, per ton	3.00

The following table gives the general facts of the experiment :

TABLE 1.—Record of each lot, December 17, 1912, to May 22, 1913—157 days.

	Lot 1	Lot 2	Lot 3	Lot 4	Lot 5	Lot 6
Number of steers in lot.	8	8	8	8	7	7
Rations fed	Corn, prairie hay, cold pressed cot- tonseed cake	Corn, corn silage, cold pressed cot- tonseed cake	Corn, corn silage, prairie hay	Corn, heavy feed of corn silage, alfalfa	Corn, medium feed of corn silage, alfalfa	Corn, alfalfa
Av. first wt. per steer, lbs.	944.00	939.00	919.00	975.00	985.00	945.00
Av. last wt. per steer, lbs.	1,247.00	1,254.00	1,194.00	1,327.00	1,306.00	1,305.00
Total gain per steer, lbs.	303.00	315.00	275.00	352.00	321.00	360.00
Av. daily gain, lbs.	1.93	2.01	1.75	2.24	2.04	2.29
Total feed consumed, lbs. —						
Corn	22,643.26	18,351.05	20,276.75	19,091.45	17,408.00	19,477.06
Prairie hay	5,079.50		4,101.75			
Cold pressed cottonseed cake	3,409.57	3,387.36				
Straw	1,256.00	1,256.00	1,256.00	1,256.00	1,099.00	1,099.00
Corn silage		35,934.50	20,746.50	32,755.50	18,290.00	
Alfalfa				6,331.00	6,798.50	8,498.50
Feed required for 100 lbs. gain—						
Corn	934.12	728.00	922.00	677.96	774.72	772.90
Prairie hay	209.55		186.30			
Cold pressed cottonseed cake	140.66	134.40				
Straw	51.82	49.85	57.10	44.60	48.91	43.61
Corn silage		1,426.00	944.00	1,163.21	813.97	
Alfalfa				224.82	302.56	337.24
Cost of 100 lbs. gain.	\$9.51	\$9.29	\$9.08	\$7.79	\$8.31	\$7.22
Av. cost per steer—						
Initial cost	59.00	58.69	57.44	60.94	61.56	59.06
Cost of feed	28.82	29.26	24.97	27.42	26.68	25.99
Cost of marketing	3.12	3.14	2.99	3.32	3.27	3.26
Total	90.94	91.09	85.40	91.68	91.51	88.31
Price necessary to pay for food con- sumed	7.29	7.26	7.15	6.91	7.01	6.78
Av. price received per steer	100.36	98.40	94.33	106.18	104.98	108.90
Net profit per steer	9.42	7.31	8.93	14.50	13.47	20.59

In computing the financial returns the customary practice was followed of letting the manure produced by the steers offset the interest on the investment and the cost of labor involved in feeding. Eight per cent interest on the money paid for the steers would amount to approximately \$2.70 per head for the 200 days that the steers were in the feed yards. Cooperative experiments conducted by the Agronomy Department of the University of Nebraska with various farmers in the State indicate that, on the average Nebraska farm, manure has a valuation of about \$2.50 per ton. This being true, the manure produced by the steers on experiment would more than pay the cost of feeding and the interest on the investment.

It will be noted that Lot 1, fed corn, prairie hay, and cold pressed cottonseed cake, made less gains than Lot 2, fed corn, silage, and cold pressed cottonseed cake. The steers in Lot 1, however, yielded the greater profit, owing to the fact that they sold at a higher price.

Lot 3, fed corn, silage, and prairie hay, made less gains than either Lots 1 or 2. In cost of 100 pounds gain, however, Lot 3 was the cheapest of the 3 lots, and more profit was made on the steers in Lot 3 than was made on the steers in Lot 2. When the steers were sold, it was noted that the animals in Lots 2 and 3 were in the poorest condition of any in the experiment. A number of the steers in Lot 3 did not shed their coats when warm weather came and consequently made a rough appearance. In this connection, it might be stated that the steers receiving silage, without exception, shed their coats early in the spring and at all times presented a sleek and sappy appearance. The same was true to a less degree with the steers in Lot 6, getting a ration of alfalfa hay and corn.

Lot 5, fed a ration of alfalfa hay, a medium feed of silage, and corn, made faster and cheaper gains than Lot 3, fed the same amount of silage and corn as Lot 5, but getting prairie hay instead of alfalfa. The results from these two lots give additional proof of the superiority of alfalfa hay as a roughage for fattening steers. Lots 4, 5, and 6, receiving alfalfa hay, made faster and cheaper gains than did Lots 1, 2, and 3, which did not receive alfalfa. In this test, if the alfalfa hay had cost \$20 per ton, the lots receiving alfalfa would still have returned a larger average profit per steer than the average profit per steer of the best one of the other lots.

Where a heavy ration of silage, alfalfa hay, and corn was compared with a medium ration of silage, alfalfa hay, and corn in Lots 4 and 5, the steers fed the heavy ration of silage made faster

gains and returned more profit. This is somewhat contrary to results secured in a previous test,* and for that reason the question of how much silage should be fed to secure the greatest profit apparently must be considered as far from being settled. It would seem that the amount of silage which can best be used in the fattening steer ration may vary with different animals and different feeding conditions.

Ten days after the experiment closed, the steers were sold on the South Omaha market. Since it is interesting to compare the shrinkages of the different lots in marketing, the average shrinkage per steer for each lot is here given, assuming that the steers gained at the average rate during the 10 days:

	Pounds
Lot 1	27
Lot 2	44
Lot 3	17
Lot 4	30
Lot 5	30
Lot 6	8

It is observed that with the exception of Lot 2 the silage-fed steers suffered a light shrink. All of the steers in the test were fed an exclusive prairie hay ration for 24 hours before they were shipped. If some such practice as this is adopted, it is probable that silage-fed steers will not lose any more weight in marketing than will steers not fed silage.

Lot 2, which suffered the heaviest shrinkage of any lot in the experiment, was the only lot not fed hay. Each of Lots 4 and 5, fed corn, silage, and alfalfa hay, lost practically the same number of pounds. The different amounts of silage which these 2 lots were fed seemingly had no effect upon the number of pounds of shrinkage which they sustained in marketing. Lot 3 shrunk 17 pounds and Lot 6 shrunk 8 pounds. There is little doubt but that Lots 3 and 6 had a better fill after reaching the stockyards than did the other lots. The dressing percentages of the different lots would seem to bear out such a conclusion.

Owing to the courtesy of Morris & Co., who bought the steers, the dressing percentages of the various lots were obtained. These percentages as given below are based on the shrunk weights of the steers, the shrunk weights being calculated by taking 98 per cent of the weights of the warm carcasses. This calculation gives the approximate weights of the carcasses when cold. Lot 1 dressed 61.65 per cent; Lot 2 dressed 61.28 per cent; Lot 3 dressed 60.52

* See Bul. 132, p. 33, Agr. Exp. Station of Nebr.

per cent; Lot 4 dressed 60.94 per cent; Lot 5 dressed 61.52 per cent; and Lot 6 dressed 60.71 per cent.

These figures show that the steers in Lot 3 were poorer killers than the steers in any other lot. By referring to the table giving the feeding records, it will also be noted that Lot 3 made the smallest gain of any lot in the experiment. It does not follow, however, that the lot which dressed the highest percentage of carcass made the fastest gain. On the contrary it will be observed that Lot 1, which made the second poorest gain of any lot in the experiment, dressed out the best of any lot. Furthermore, Lot 6, which made the largest gain of any lot, ranked next to Lot 3 (the one making the poorest gain) in dressing percentage. As has been stated previously, the comparatively low dressing percentage of Lot 6 can probably be largely traced to the fill which this lot took after reaching the market. Other things being equal, the percentage of carcass that an animal will dress should vary directly with the condition of flesh of the animal.

In order to show something regarding the differences which exist between various steers in their abilities to make economical gains, tables showing the records of the individual steers in the different lots follow:

TABLE 2.—*Record of each steer in Lot 1, December 17, 1912, to May 22, 1913.*
 Ration—Corn, prairie hay, and cold pressed cottonseed cake.

Number of each steer	1	2	3	4	5	6	7	8	Av. of lot
First wt. of each steer, lbs.	960.00	871.00	976.00	930.00	962.00	981.00	882.00	991.00	944.10
Final wt. of each steer, lbs.	1,250.00	1,175.00	1,306.00	1,193.00	1,230.00	1,361.00	1,189.00	1,270.00	1,246.80
Total gain of each steer, lbs.	290.00	304.00	330.00	263.00	268.00	380.00	307.00	279.00	302.60
Av. daily gain, lbs.	1.85	1.94	2.10	1.67	1.71	2.42	1.96	1.78	1.93
Av. amt. corn consumed daily, lbs.	18.29	17.91	18.32	17.77	17.84	18.22	17.96	17.92	18.03
Av. amt. prairie hay consumed daily, lbs.	4.08	4.11	4.18	4.08	4.03	4.08	3.96	3.81	4.04
Av. amt. cottonseed cake consumed daily, lbs.	2.77	2.74	2.73	2.70	2.57	2.77	2.74	2.69	2.71
Av. amt. straw consumed daily, lbs.	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
Corn consumed for 100 lbs. gain, lbs.	988.65	923.71	872.33	1,064.07	1,043.27	752.89	916.33	1,006.74	934.12
Prairie hay consumed for 100 lbs. gain, lbs.	220.54	211.86	199.05	244.31	235.67	168.60	202.04	214.04	209.55
Cottonseed cake for 100 lbs. gain, lbs.	149.73	141.24	130.00	161.68	150.29	114.46	139.80	151.12	140.66
Straw consumed for 100 lbs. gain, lbs.	54.05	51.55	47.62	59.88	58.45	41.32	51.02	56.18	51.82
Cost of food for 100 lbs. gain	\$10.06	\$9.44	\$8.87	\$10.87	\$10.54	\$8.23	\$9.33	10.20	\$9.51

TABLE 3.—*Record of each steer in Lot 2, December 17, 1912, to May 22, 1913.*
 Ration—Corn, corn silage, and cold pressed cottonseed cake.

Number of each steer . . .	9	10	11	12	13	14	15	16	Av. of lot
First wt. of each steer, lbs.	888.00	984.00	834.00	984.00	961.00	912.00	951.00	998.00	939.00
Final wt. of each steer, lbs.	1,186.00	1,320.00	1,098.00	1,287.00	1,328.00	1,290.00	1,258.00	1,267.00	1,254.00
Total gain of each steer, lbs.	298.00	336.00	264.00	303.00	367.00	378.00	307.00	269.00	315.00
Av. daily gain each steer, lbs.	1.90	2.14	1.68	1.93	2.34	2.41	1.96	1.71	2.01
Av. amt. of corn consumed daily, lbs.	13.84	15.12	15.04	14.46	15.06	14.20	14.71	14.44	14.61
Av. amt. of silage consumed daily, lbs.	29.38	27.74	28.05	29.17	29.69	29.41	28.29	27.14	28.61
Av. amt. of cottonseed cake consumed daily, lbs.	2.73	2.73	2.67	2.73	2.73	2.73	2.65	2.55	2.69
Av. amt. of straw consumed daily, lbs.	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
Corn consumed for 100 lbs. gain, lbs.	728.42	706.54	895.24	749.22	643.59	589.25	750.51	844.44	728.00
Silage consumed for 100 lbs. gain, lbs.	1,546.32	1,296.26	1,669.64	1,511.40	1,268.80	1,220.33	1,443.37	1,587.13	1,426.00
Cottonseed cake consumed for 100 lbs. gain, lbs.	143.68	127.57	158.93	141.45	116.67	113.28	135.20	149.12	134.40
Straw consumed for 100 lbs. gain, lbs.	52.63	46.73	59.52	51.81	42.74	41.49	51.02	58.48	49.85
Cost of food for 100 lbs. gain	\$9.59	\$8.84	\$11.22	\$9.66	\$8.19	\$7.67	\$9.49	\$10.59	\$9.29

Corn Silage and Alfalfa for Beef Production.

TABLE 4.—*Record of each steer in Lot 3, December 17, 1912, to May 22, 1913.*

Ration—Corn, corn silage, and prairie hay.										
Number of each steer		17	18	19	20	21	22	23	24	Av. of lot
First wt. of each steer, lbs.		928.00	906.00	944.00	928.00	943.00	970.00	841.00	892.00	919.00
Final wt. of each steer, lbs.		1,212.00	1,160.00	1,217.00	1,173.00	1,260.00	1,253.00	1,140.00	1,135.00	1,193.75
Total gain of each steer, lbs.		284.00	254.00	273.00	245.00	317.00	283.00	299.00	243.00	274.75
Av. daily gain each steer, lbs.		1.81	1.62	1.74	1.56	2.02	1.80	1.90	1.55	1.75
Av. amt. of corn consumed daily, lbs.		16.25	16.41	15.93	16.42	16.16	16.38	15.61	15.99	16.14
Av. amt. of silage consumed daily, lbs.		16.96	15.14	17.17	16.93	16.85	16.92	16.45	16.36	16.52
Av. amt. of hay consumed daily, lbs.		3.31	3.41	3.33	3.40	3.18	3.25	3.12	3.11	3.26
Av. amt. of straw consumed daily, lbs.		1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
Corn consumed for 100 lbs. gain, lbs.		898.23	1,012.96	915.52	1,052.56	800.00	910.00	821.58	1,031.61	922.00
Silage consumed for 100 lbs. gain, lbs.		937.00	934.57	986.78	1,085.26	834.15	940.00	865.79	1,055.48	944.00
Prairie hay consumed for 100 lbs. gain, lbs.		182.87	210.49	191.38	217.95	157.43	180.56	164.21	200.65	186.30
Straw consumed for 100 lbs. gain, lbs.		55.25	61.73	57.47	64.11	49.50	55.56	52.63	64.52	57.10
Cost of food for 100 lbs. gain		\$8.87	\$9.83	\$9.10	\$10.38	\$7.88	\$8.95	\$8.11	\$10.12	\$9.08

TABLE 5.—Record of each steer in Lot 4, December 17, 1912, to May 22, 1913.
Ration—Corn, heavy feed of silage, and alfalfa.

Number of each steer.	25	26	27	28	29	30	31	32	Av. of lot
First wt. of each steer, lbs.	964.00	940.00	980.00	866.00	990.00	1,037.00	991.00	1,035.00	975.38
Final wt. of each steer, lbs.	1,347.00	1,363.00	1,262.00	1,225.00	1,328.00	1,368.00	1,365.00	1,357.00	1,326.87
Total gain of each steer, lbs.	383.00	423.00	282.00	359.00	338.00	331.00	374.00	322.00	351.49
Av. daily gain each steer, lbs.	2.44	2.69	1.80	2.29	2.15	2.11	2.38	2.05	2.24
Av. amt. corn consumed daily, lbs.	15.27	15.34	15.16	14.53	15.34	15.31	15.33	15.31	15.20
Av. amt. silage consumed daily, lbs.	26.39	26.63	25.28	26.89	26.57	23.88	27.15	25.91	26.09
Av. amt. alfalfa consumed daily, lbs.	5.07	5.10	4.96	4.95	5.04	5.11	5.10	5.00	5.04
Av. amt. straw consumed daily, lbs.	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
Corn consumed for 100 lbs. gain, lbs.	625.82	570.26	842.22	634.50	713.49	725.59	644.12	748.29	677.96
Silage consumed for 100 lbs. gain, lbs.	1,081.56	989.96	1,404.44	1,174.24	1,235.81	1,131.75	1,140.76	1,263.90	1,163.21
Alfalfa consumed for 100 lbs. gain, lbs.	207.79	189.59	275.56	216.16	234.42	242.19	214.29	243.90	224.82
Straw consumed for 100 lbs. gain, lbs.	40.98	37.17	55.56	43.67	46.51	47.39	42.02	48.78	44.60
Cost of food for 100 lbs. gain	\$7.20	\$6.58	\$9.61	\$7.45	\$8.21	\$8.18	\$7.46	\$8.56	\$7.79

TABLE 6.—*Record of each steer in Lot 5, December 17, 1912, to May 22, 1913.*
 Ration—Corn, medium feed of silage, and alfalfa.

Number of each steer.....	33	34	35	36	38	39	40	Av. of lot
First wt. of each steer, lbs.....	989.00	963.00	996.00	938.00	971.00	988.00	1,051.00	985.14
Final wt. of each steer, lbs.....	1,340.00	1,300.00	1,345.00	1,285.00	1,238.00	1,347.00	1,285.00	1,305.71
Total gain of each steer, lbs.....	351.00	337.00	349.00	347.00	267.00	359.00	234.00	320.57
Av. daily gain, lbs.....	2.24	2.15	2.22	2.21	1.70	2.29	1.49	2.04
Av. amt. corn consumed daily, lbs..	15.23	15.96	16.39	16.22	15.81	16.41	15.02	15.86
Av. amt. silage consumed daily, lbs..	16.96	17.02	17.24	16.58	16.87	16.40	15.42	16.64
Av. amt. alfalfa consumed daily, lbs..	6.08	6.20	6.26	6.14	6.20	6.19	6.24	6.19
Av. amt. straw consumed daily, lbs..	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
Corn consumed for 100 lbs. gain, lbs.	679.91	742.33	738.29	733.94	930.00	716.59	1,008.05	774.72
Silage consumed for 100 lbs. gain, lbs.	757.14	791.63	776.57	750.23	992.35	716.16	1,034.90	813.97
Alfalfa consumed for 100 lbs. gain, lbs.	271.43	288.37	281.98	277.83	364.71	270.31	418.79	302.56
Straw consumed for 100 lbs. gain, lbs.	44.64	46.51	45.05	45.29	58.82	43.67	67.11	48.91
Cost of food for 100 lbs. gain.....	\$7.40	\$7.98	\$7.90	\$7.81	\$10.03	\$7.59	\$10.89	\$8.31

TABLE 7.—Record of each steer in Lot 6, December 17, 1912, to May 22, 1913.
Ration—Corn and alfalfa.

Number of each steer.....	41	42	43	44	45	46	47	Av. of lot
First wt. of each steer, lbs.....	899.00	959.00	1,043.00	848.00	832.00	1,067.00	966.00	944.85
Final wt. of each steer, lbs.....	1,268.00	1,243.00	1,358.00	1,258.00	1,215.00	1,457.00	1,335.00	1,304.85
Total gain of each steer, lbs.....	369.00	284.00	315.00	410.00	383.00	390.00	369.00	360.00
Av. daily gain, lbs.....	2.35	1.81	2.01	2.61	2.44	2.48	2.35	2.29
Av. amt. corn consumed daily, lbs.....	17.40	17.08	17.44	18.24	17.38	18.26	18.26	17.72
Av. amt. alfalfa consumed daily, lbs.....	7.71	7.57	7.83	7.79	7.61	7.74	7.88	7.73
Av. amt. straw consumed daily, lbs.....	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
Corn consumed for 100 lbs. gain, lbs.....	740.43	943.65	867.66	698.85	712.30	736.29	777.02	772.10
Alfalfa consumed for 100 lbs. gain, lbs.....	328.09	418.23	389.55	298.47	211.89	312.10	335.32	337.24
Straw consumed for 100 lbs. gain, lbs.....	42.55	55.25	49.75	38.31	40.98	40.32	42.55	43.61
Cost of food for 100 lbs. gain.....	\$6.93	\$8.83	\$8.14	\$6.49	\$6.65	\$6.83	\$7.23	\$7.22

It will be observed by studying the individual records that the largest individual gain was made by steer No. 26 in Lot 4, fed a ration of corn, alfalfa, and a heavy feed of silage. The average gain per steer in Lot 4, however, was less than that of Lot 6, where a ration of corn and alfalfa hay was fed.

Steer No. 40 in Lot 5, given a ration of corn, alfalfa, and a medium feed of silage, made the smallest gain of any steer in the test. In spite of this fact, in the average gain per steer, Lot 5 ranked higher than three other lots in the test.

That the individuality of a steer is a very important factor in feeding operations is indicated by the fact that the highest gaining steer was not in the lot showing the highest average gain. Neither was the steer showing the lowest gain in the lot having the lowest average gain. The steers in each separate lot were fed and cared for in exactly the same way and yet a study of the individual records for the different lots will show a variation between the highest and lowest gaining steers in Lot 4 of 141 pounds and an average difference between the highest and lowest gaining steers in each of the six lots of 118 pounds. The probability that several of these naturally high gaining steers will be gathered together in one lot is worth consideration by any experimenter who attempts to draw conclusions from feeding experiments which contain small numbers of cattle.

Lot 3, fed a ration of corn, silage, and prairie hay, made the least average gain of any lot. If all of the steers in Lot 3 had made as large individual gains as did No. 21, the steer which made the best gain of any steer in this lot, the average gain for the lot would still have been less than the average gain of any one of Lots 4, 5, and 6.

Two steers in Lot 6 made smaller individual gains than did the best steer in Lot 3. Yet the average gain per steer in Lot 6 was greater than the gain made by the best steer in Lot 3, while the average gain per steer in Lot 3 was less than the gain made by the poorest steer in Lot 6.

If steers Nos. 38 and 40 had been removed from Lot 5, the average daily gain per steer for this lot would have been 2.22 pounds instead of 2.04 pounds. In other words, the effect of two individuals in this lot was sufficient to lower the average daily gain 0.18 of a pound. This shows that the average feeding results from a group made up of a few animals cannot be regarded as definite, owing to the widely differing characteristics of the individuals in the group. On this account, unless a large number of animals is used in a feeding experiment, individual records of the animals are very valuable. In the case of Lot 5, even had

steers Nos. 38 and 40 been removed, the relative ranking of the lots, according to their average daily gains, would have remained unchanged.

If the best gaining steer in all of the lots had been removed, the average daily gains for the lots would have been 2.24 pounds for Lot 6; 2.18 pounds for Lot 4; 2 pounds for Lot 5; 1.95 pounds for Lot 2; 1.86 pounds for Lot 1; and 1.71 pounds for Lot 3. In this case the ranking of the lots for average daily gain would be the same as it was with all steers included in the test.

EXPERIMENT 2.

In order to secure additional evidence concerning the value of corn silage in a ration for fattening steers and to get more information on the feeding of alfalfa hay, a second experiment was conducted during the winter of 1913-14.

In this experiment, 64 head of two-year-old steers were used. These steers, like the ones used in the 1912-13 tests, were grades of the Hereford and Shorthorn breeds, raised on the ranges of western Nebraska. They were purchased on the South Omaha market during the latter part of October. Until December 11, when they were started on their experimental rations, they were handled in the same manner as were the steers used in the previous test.

RATIONS USED.

On December 11 the steers were divided into eight lots and given the following rations:

Lot 1.—Ground corn and alfalfa hay.

Lot 2.—Ground corn, alfalfa hay, and wheat straw.

Lot 3.—Ground corn, alfalfa hay, and a light feed of silage.

Lot 4.—Ground corn, a medium feed of silage, and alfalfa hay.

Lot 5.—Ground corn, a heavy feed of silage, and alfalfa hay.

Lot 6.—Ground corn, alfalfa hay, and a heavy feed of silage at the beginning which gradually decreased to a light feed at the close of the feeding period.

Lot 7.—Ground corn, alfalfa hay, a medium feed of silage, and cold pressed cottonseed cake.

Lot 8.—Ground corn, a heavy feed of silage, cold pressed cottonseed cake, and alfalfa hay during the first five weeks.

As in the preceding test, all of the steers, excepting those in Lot 2, received 1 pound of straw daily in addition to the feeds stated above. Since wheat straw is much more abundant on Nebraska farms than is oat straw, wheat straw was used in this experiment.

The amounts of silage fed daily at the beginning and close of the test to each steer in Lots 3, 4, 5, 6, 7, and 8 were as follows: Lot 3 received 10 pounds thruout the test, Lot 4 received 20 pounds at the beginning and 16 pounds at the close, Lot 5 received 30 pounds (all the steers would eat) at the beginning and 19 pounds at the close, Lot 6 received 28 pounds (all the steers would eat) at the beginning and 13 pounds at the close, Lot 7 received 20 pounds at the beginning and 16 pounds at the close, Lot 8 received 28 pounds (all the steers would eat) at the beginning and 20 pounds (all the steers would eat) at the close.

The feeds used in the experiment were of good quality excepting the silage. On account of an extended period of dry weather during the year 1913, the corn crop in Nebraska was seriously injured. Consequently many fields of corn grew little or no grain. The corn put into the silos at the Experiment Station contained just a trace of grain. Undoubtedly such silage would not make as valuable feed as would normal silage. The silage, however, contained normal amounts of water and acids and the live stock ate it with considerable relish.

Soon after the experiment began, two steers were taken out of each of Lots 1 and 2, and one steer taken out of Lot 8. This left but 6 steers in each of the first two lots and 7 steers in Lot 8.

The management of the steers while on feed was essentially the same as that of the steers in the first experiment. The experiment closed on May 15, when the steers had been on feed 154 days.

PRICES OF FEEDS.

The prices of the feeds used in the experiment were based, as in the previous test, upon the prices prevailing on the average Nebraska farm at the time the experiment was in progress—

Ground corn, per bushel.....	\$0.65
Alfalfa hay, per ton.....	10.00
Corn silage, per ton	3.50
Cold pressed cottonseed cake, per ton.....	26.00
Wheat straw, per ton	2.00

As compared with the prices of feeds used in the 1912-13 experiment, it will be noted that the prices given here are much higher. This is particularly true of corn, which has a valuation of 23 cents per bushel above the valuation of the corn used in the 1912-13 test.

TABLE 8.—*Record of each lot, December 11, 1913, to May 15, 1914—154 days.*

Number of steers in lot	Lot 1 6	Lot 2 6	Lot 3 8	Lot 4 8	Lot 5 8	Lot 6 8	Lot 7 8	Lot 8 7
Rations fed	Corn, alfalfa	Corn, alfalfa, straw	Corn, alfalfa, light feed of silage	Corn, alfalfa, medium feed of silage	Corn, alfalfa, heavy feed of silage	Corn, alfalfa, silage heavy feed at beginning, light feed at close	Corn, alfalfa, feed of silage, pressed cottonseed cake	Corn, silage, cold pressed cottonseed cake, alfalfa, first five weeks
Av. first wt. per steer, lbs.	896.00	941.00	921.00	910.00	932.00	940.00	945.00	927.00
Av. last wt. per steer, lbs.	1,220.00	1,227.00	1,244.00	1,234.00	1,255.00	1,259.00	1,260.00	1,246.00
Total gain per steer, lbs.	324.00	286.00	323.00	324.00	323.00	319.00	315.00	319.00
Av. daily gain, lbs.	2.10	1.86	2.10	2.10	2.10	2.07	2.05	2.07
Total feed consumed—								
Corn	15,552.00	15,502.00	20,889.00	20,736.00	20,184.00	20,242.50	18,902.50	17,819.00
Alfalfa	5,793.00	5,618.00	5,460.00	4,754.00	3,956.00	4,111.00	4,337.00	982.50
Straw	929.00	2,016.00	1,238.00	1,239.00	1,238.00	1,238.00	1,240.00	1,072.00
Silage			12,072.50	22,566.00	27,429.00	20,901.00	21,407.00	20,655.00
Cottonseed cake							1,722.00	2,769.00
Feed required for 100 lbs. gain—								
Corn	800.00	903.40	808.40	800.00	781.10	793.20	750.10	798.00
Alfalfa	298.00	327.40	211.30	183.40	153.10	161.10	172.10	44.00
Straw	47.80	117.50	47.90	47.80	47.90	48.50	49.20	48.00
Silage			467.20	870.60	1,061.50	819.00	849.50	925.00
Cottonseed cake							72.30	124.00
Cost of 100 lbs. gain	10.82	12.23	11.31	11.77	11.74	11.49	12.04	12.76
Av. cost per steer—								
Initial cost	\$65.41	\$68.69	\$67.23	\$66.43	\$68.04	\$68.62	\$68.98	\$67.67
Cost of feed	35.05	34.98	36.34	38.14	37.90	36.65	37.92	40.69
Cost of marketing	3.05	3.07	3.11	3.08	3.14	3.15	3.15	3.11
Total	103.51	106.74	106.68	107.65	109.08	108.42	110.05	111.47
Price necessary in order to break even	8.48	8.70	8.58	8.72	8.69	8.61	8.73	8.95
Av. price received per steer	103.36	102.52	107.10	103.54	106.73	105.00	104.16	105.17
Net profit per steer	.15	4.22	.42	Loss 4.11	Loss 2.35	Loss 3.42	Loss 5.89	Loss 6.30

In making up the financial tables the method of calculation was the same as in the preceding experiment.

Perhaps the most striking thing about the results of this test is the fact that Lots 1, 3, 4, and 5 made almost identical gains, while Lots 6, 7, and 8 also made practically the same gains. The differences in rates of gain between any two of the seven lots mentioned were not sufficient to warrant conclusions as to the relative nutritive values of the rations. However, there was a considerable difference in the costs of 100 pounds gain.

It will be noted that Lot 1, fed a ration of corn and alfalfa hay, made the cheapest gains, while Lot 8, fed a ration of corn, silage, and cold pressed cottonseed cake, made the most expensive gains. Comparing Lot 8 with Lot 7, it will be observed that the feeding of alfalfa hay in Lot 7, while not increasing the rate of gain, lowered the cost of gain 72 cents per hundred pounds. Lot 7 made more expensive gains than Lot 4 which was fed similar to Lot 7 except that Lot 4 did not receive cottonseed cake. From the results of this test, it would appear that it is doubtful if cold pressed cottonseed cake can be profitably added to a ration of corn and alfalfa hay for fattening steers.

Lot 1, fed a ration of corn and alfalfa hay, made cheaper gains than any other lot in the test. This substantiates results which were secured in the test conducted during the winter of 1912-13. In the present case, however, it will be noted that Lot 1 did not show up financially quite so well as did Lot 3. This was due to the fact that Lot 3 sold for 20 cents per 100 pounds more than did Lot 1. Despite this fact, the steers in Lot 1 dressed out a higher percentage of beef than did the steers in Lot 3.

In contrast to the results obtained in the 1912-13 experiment, all of the steers except those in Lot 3 were fed at a loss. In the case of Lot 1 the loss was slight, but in the other lots it was quite heavy. This loss can largely be traced to two causes, first to the rather small margin between the buying and selling prices of the steers and second to the high price paid for corn.

Lots 1, 4, and 5 respectively were fed the same rations as Lots 6, 5, and 4 in the first experiment. In feed required for 100 pounds gain, Lot 1 of the 1913-14 experiment used 27 pounds more corn and 39 pounds less alfalfa hay than did Lot 6 of the 1912-13 experiment. Lot 4 of the 1913-14 experiment used 26 pounds more corn, 56 pounds more silage, and 119 pounds less alfalfa for 100 pounds gain than did Lot 5 in the 1912-13 experiment. Lot 5 of the 1913-14 experiment used 115 pounds more corn, 344 pounds less silage, and 63 pounds less alfalfa hay for 100 pounds gain than did Lot 4 of the 1912-13 experiment. Without excep-

tion, the steers in the 1913-14 test used more corn and less alfalfa hay for 100 pounds gain than did the steers in the 1912-13 test. This may have been due partly to weather conditions inasmuch as there was much more stormy and disagreeable weather during the time the 1913-14 experiment was in progress than there was during the previous test. It, however, suggests the variability from year to year that may be expected in cattle feeding operations.

TABLE 9.—*Record of each steer in Lot 1, December 11, 1913, to May 15, 1914.*
 Ration—Corn and alfalfa.

Number of each steer	1	2	3	4	5	7	Av. of lot
First wt. of each steer, lbs.....	1,028.00	759.00	912.00	852.00	897.00	928.00	896.00
Final wt. of each steer, lbs.....	1,425.00	1,020.00	1,228.00	1,202.00	1,180.00	1,265.00	1,220.00
Total gain of each steer, lbs.....	397.00	261.00	316.00	350.00	283.00	337.00	324.00
Av. daily gain each steer, lbs.....	2.58	1.69	2.05	2.27	1.84	2.19	2.10
Av. amt. of corn consumed daily, lbs..	1.84	14.30	17.10	16.80	15.90	18.40	16.80
Av. amt. of alfalfa consumed daily, lbs.	7.00	6.10	5.80	6.10	6.00	6.60	6.27
Av. amt. of straw consumed daily, lbs.....	1.00	1.00	1.00	1.00	1.00	1.00	1.00
Corn consumed for 100 lbs. gain, lbs.....	714.10	846.40	835.30	737.30	867.30	841.00	800.00
Alfalfa consumed for 100 lbs. gain, lbs.....	272.50	360.90	280.70	269.00	325.60	302.60	298.00
Straw consumed for 100 lbs. gain, lbs.....	39.00	59.40	49.00	44.30	54.80	46.00	47.80
Cost of food for 100 lbs. gain	\$9.70	\$11.70	\$11.16	\$9.96	\$11.77	\$11.34	\$10.72



Fig. 1.—No. 1, best gaining steer in Lot 1.



Fig. 2.—No. 5, poorest gaining steer in Lot 1.

TABLE 10.—*Record of each steer in Lot 2, December 11, 1913, to May 15, 1914.*
 Ration—Corn, alfalfa, and straw.

Number of each steer	9	11	12	13	14	15	Average of lot
First wt. of each steer, lbs.	878.00	946.00	864.00	1,022.00	1,021.00	917.00	941.00
Final wt. of each steer, lbs.	1,203.00	1,255.00	1,113.00	1,258.00	1,280.00	1,250.00	1,227.00
Total gain of each steer, lbs.	325.00	309.00	249.00	236.00	259.00	333.00	286.00
Av. daily gain each steer, lbs.	2.11	2.01	1.62	1.53	1.68	2.16	1.86
Av. amt. of corn consumed daily, lbs.	17.70	16.63	14.47	16.53	17.21	18.04	16.77
Av. amt. of alfalfa consumed daily, lbs.	6.28	6.00	5.81	6.03	6.11	6.24	6.08
Av. amt. of straw consumed daily, lbs.	2.50	1.48	2.02	2.61	2.13	2.34	2.18
Corn consumed for 100 lbs. gain, lbs.	840.70	829.00	895.80	1,079.20	1,023.60	834.50	903.40
Alfalfa consumed for 100 lbs. gain, lbs.	297.40	299.00	359.80	393.60	363.30	288.90	327.40
Straw consumed for 100 lbs. gain, lbs.	118.80	74.10	124.70	170.30	126.60	108.20	117.50
Cost of food for 100 lbs. gain	\$12.38	\$11.21	\$12.34	\$14.68	\$13.84	\$11.27	\$12.23

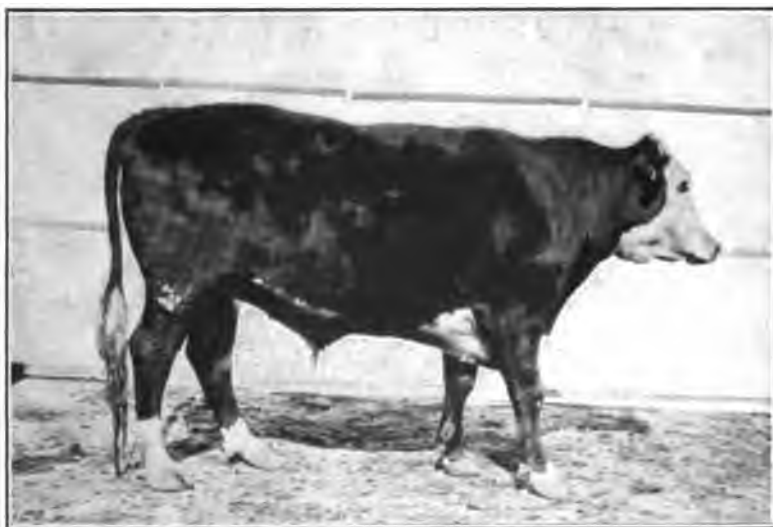


Fig. 3.—No. 15, best gaining steer in Lot 2.



Fig. 4.—No. 13, poorest gaining steer in Lot 2.

Corn Silage and Alfalfa for Beef Production.

TABLE 11.—Record of each steer in Lot 3, December 11, 1913, to May 15, 1914.
Ration—Corn, alfalfa, and light feed of silage.

Number of each steer. . . .	17	18	19	20	21	22	23	24	Av. of lot
First wt. of each steer, lbs.	975.00	710.00	884.00	886.00	920.00	951.00	1,008.00	1,035.00	921.00
Final wt. of each steer, lbs.	1,310.00	1,035.00	1,255.00	1,213.00	1,210.00	1,213.00	1,335.00	1,377.00	1,244.00
Total gain of each steer, lbs.	335.00	325.00	371.00	327.00	290.00	262.00	327.00	342.00	323.00
Av. daily gain, lbs. . . .	2.17	2.11	2.41	2.12	1.88	1.70	2.12	2.22	2.10
Av. amt. corn consumed daily, lbs.	17.43	16.29	17.27	16.94	17.15	16.03	17.09	17.41	16.90
Av. amt. alfalfa consumed daily, lbs.	4.49	3.91	4.43	4.35	4.57	4.26	4.99	4.43	4.40
Av. amt. silage consumed daily, lbs.	10.01	9.35	9.68	9.81	9.78	9.93	9.82	9.98	9.80
Av. amt. straw consumed daily, lbs.	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
Corn consumed for 100 lbs. gain, lbs.	801.30	772.30	716.90	797.90	911.10	942.70	805.00	784.70	808.40
Alfalfa consumed for 100 lbs. gain, lbs.	206.70	185.40	184.30	205.20	242.40	250.80	235.10	199.60	211.30
Silage consumed for 100 lbs. gain, lbs.	460.30	443.20	401.90	461.80	519.80	584.20	462.50	449.40	467.20
Straw consumed for 100 lbs. gain, lbs.	46.30	47.70	41.80	47.40	53.40	59.20	47.40	45.30	47.90
Cost of food for 100 lbs. gain	\$11.20	\$10.73	\$10.00	\$11.16	\$12.77	\$13.29	\$11.39	\$10.95	\$11.30



Fig. 5.—No. 19, best gaining steer in Lot 3.



Fig. 6.—No. 22, poorest gaining steer in Lot 3.

TABLE 12.—*Record of each steer in Lot 4, December 11, 1913, to May 15, 1914.*
 Ration—Corn, alfalfa, and medium feed of silage.

Number of each steer.....	25	26	27	28	29	30	31	32	Average of lot
First wt. of each steer, lbs.	974.00	1,055.00	842.00	864.00	823.00	911.00	966.00	847.00	910.00
Final wt. of each steer, lbs.	1,302.00	1,453.00	1,162.00	1,205.00	1,102.00	1,143.00	1,337.00	1,170.00	1,234.00
Total gain of each steer, lbs.	328.00	398.00	320.00	341.00	279.00	232.00	371.00	323.00	324.00
Av. daily gain each steer, lbs.	2.13	2.58	2.08	2.21	1.81	1.51	2.41	2.09	2.10
Av. amt. corn consumed daily, lbs.	17.28	17.72	16.75	15.87	16.29	16.60	17.20	16.94	16.80
Av. amt. alfalfa consumed daily, lbs.	3.90	4.00	3.69	4.22	4.02	3.52	4.00	3.47	3.85
Av. amt. silage consumed daily, lbs.	18.17	19.24	17.76	19.38	17.63	17.73	19.24	17.33	18.30
Av. amt. straw consumed daily, lbs.	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
Corn consumed for 100 lbs. gain, lbs.	811.40	686.10	806.50	717.10	896.00	1,102.00	714.00	808.00	800.00
Alfalfa consumed for 100 lbs. gain, lbs.	183.20	155.00	177.70	190.90	222.30	234.10	166.20	165.80	183.40
Silage consumed for 100 lbs. gain, lbs.	853.50	744.70	855.20	875.70	973.70	1,177.40	798.90	826.60	870.60
Straw consumed for 100 lbs. gain, lbs.	47.30	38.90	48.40	45.50	55.60	66.80	41.80	48.00	47.80
Cost of food for 100 lbs. gain	\$11.89	\$10.09	\$11.81	\$10.87	\$13.29	\$16.11	\$10.57	\$11.72	\$11.77



Fig. 7.—No. 26, best gaining steer in Lot 4.



Fig. 8.—No. 30, poorest gaining steer in Lot 4.

TABLE 13.—*Record of each steer in Lot 5, December 11, 1913, to May 15, 1914.*
 Ration—Corn, alfalfa, and heavy feed of silage.

Number of each steer. . . .	33	34	35	36	37	38	39	40	Av. of lot
First wt. of each steer, lbs.	996.00	979.00	813.00	890.00	761.00	999.00	1,066.00	954.00	932.00
Final wt. of each steer, lbs.	1,300.00	1,365.00	1,102.00	1,166.00	1,068.00	1,300.00	1,435.00	1,302.00	1,255.00
Total gain of each steer, lbs.	304.00	386.00	289.00	276.00	307.00	301.00	369.00	348.00	323.00
Av. daily gain each steer, lbs.	1.97	2.51	1.87	1.79	1.99	1.95	2.39	2.26	2.10
Av. amt. of corn consumed daily, lbs.	17.01	17.71	16.96	14.90	16.53	14.57	16.32	16.99	16.38
Av. amt. of alfalfa consumed daily, lbs.	3.26	3.23	3.13	3.17	3.10	3.57	3.45	2.76	3.21
Av. amt. of silage consumed daily, lbs.	23.81	26.03	14.99	22.97	18.23	26.32	26.55	19.19	22.26
Av. amt. of straw consumed daily, lbs.	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
Corn consumed for 100 lbs. gain, lbs.	862.10	706.60	903.90	831.80	829.20	745.70	681.20	752.20	781.10
Alfalfa consumed for 100 lbs. gain, lbs.	165.60	129.10	167.00	177.00	155.90	182.70	144.20	122.10	153.10
Silage consumed for 100 lbs. gain, lbs.	1,206.40	1,038.70	799.00	1,281.70	914.80	1,346.80	1,108.10	849.30	1,061.50
Straw consumed for 100 lbs. gain, lbs.	51.00	40.20	53.60	56.20	50.50	51.50	42.00	44.50	47.90
Cost of food for 100 lbs. gain	\$13.47	\$10.72	\$12.79	\$12.85	\$12.07	\$11.99	\$10.62	\$10.89	\$11.73



Fig. 9.—No. 39, best gaining steer in Lot 5.

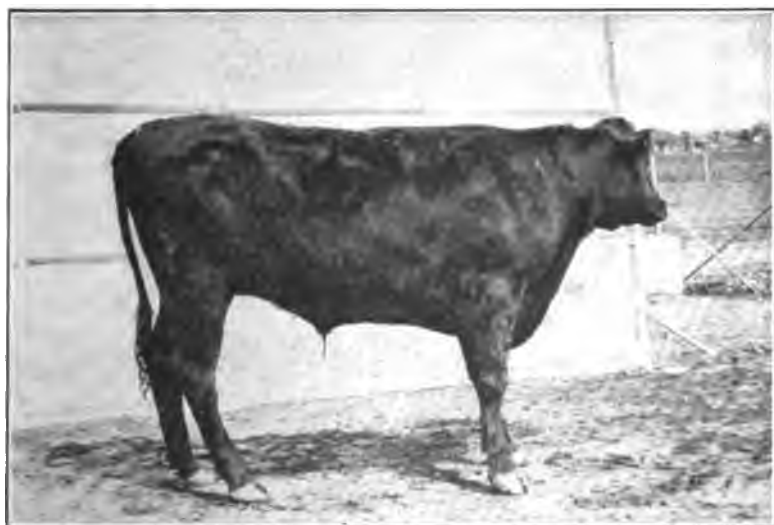


Fig. 10.—No. 36, poorest gaining steer in Lot 5.

TABLE 14.—*Record of each steer in Lot 6, December 11, 1913, to May 15, 1914.*
 Ration—Corn, alfalfa, and tapering silage.

Number of each steer.	41	42	43	44	45	46	47	48	Av. of lot
First wt. of each steer, lbs.	935.00	943.00	977.00	943.00	986.00	962.00	840.00	932.00	940.00
Final wt. of each steer, lbs.	1,300.00	1,280.00	1,318.00	1,233.00	1,250.00	1,282.00	1,128.00	1,278.00	1,259.00
Total gain of each steer, lbs.	365.00	337.00	341.00	290.00	264.00	320.00	288.00	346.00	319.00
Av. daily gain each steer, lbs.	2.37	2.19	2.21	1.88	1.71	2.08	1.87	2.24	2.07
Av. amt. of corn consumed daily, lbs.	16.59	17.07	17.51	14.13	16.36	17.35	14.79	17.62	16.43
Av. amt. of alfalfa consumed daily, lbs.	3.34	3.44	3.53	3.32	2.60	3.67	3.16	3.63	3.33
Av. amt. of silage consumed daily, lbs.	18.69	16.44	18.12	18.27	15.74	14.68	15.16	18.62	16.96
Av. amt. of straw consumed daily, lbs.	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
Corn consumed for 100 lbs. gain, lbs.	700.00	780.40	791.10	750.50	954.30	834.90	791.10	784.50	793.20
Alfalfa consumed for 100 lbs. gain, lbs.	141.10	157.40	159.50	176.40	151.70	176.70	169.10	161.60	161.10
Silage consumed for 100 lbs. gain, lbs.	788.80	751.50	818.80	970.50	917.00	706.70	810.80	828.80	819.00
Straw consumed for 100 lbs. gain, lbs.	42.50	46.00	45.50	53.40	38.70	48.40	53.80	44.80	48.50
Cost of food for 100 lbs. gain	\$10.27	\$11.22	\$11.46	\$11.36	\$13.52	\$11.87	\$11.51	\$11.42	\$11.49



Fig. 11.—No. 41, best gaining steer in Lot 6.



Fig. 12.—No. 45, poorest gaining steer in Lot 6.

TABLE 15.—*Record of each steer in Lot 7, December 11, 1913, to May 15, 1914.*
 Ration—Corn, alfalfa, silage, and cottonseed cake.

Number of each steer.	49	50	51	52	53	54	55	56	Av. of lot
First wt. of each steer, lbs. .	1,019.00	852.00	986.00	1,016.00	720.00	1,020.00	978.00	966.00	945.00
Final wt. of each steer, lbs. .	1,302.00	1,160.00	1,345.00	1,312.00	963.00	1,355.00	1,353.00	1,290.00	1,260.00
Total gain of each steer, lbs. .	283.00	308.00	359.00	296.00	243.00	335.00	375.00	324.00	315.00
Av. daily gain each steer, lbs. .	1.84	2.00	2.33	1.92	1.58	2.17	2.43	2.10	2.05
Av. amt. of corn consumed daily, lbs.	16.45	15.88	15.58	14.82	13.03	16.32	15.96	14.66	15.34
Av. amt. of alfalfa consumed daily, lbs.	3.62	3.42	3.92	3.89	2.44	3.58	3.78	3.51	3.52
Av. amt. of silage consumed daily, lbs.	16.86	14.42	19.45	19.32	11.82	18.55	19.36	19.20	17.37
Av. amt. of cottonseed cake consumed daily, lbs.	1.48	1.48	1.48	1.48	1.47	1.48	1.47	1.48	1.48
Av. amt. of straw consumed daily, lbs.	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
Corn consumed for 100 lbs. gain, lbs.	895.50	794.40	668.60	771.20	826.20	750.50	655.80	697.00	750.10
Alfalfa consumed for 100 lbs. gain, lbs.	197.00	171.10	168.10	202.70	154.70	164.50	155.30	167.10	172.10
Silage consumed for 100 lbs. gain, lbs.	917.50	721.40	834.50	1,005.40	749.20	853.00	795.10	912.70	849.50
Cottonseed cake consumed for 100 lbs. gain, lbs.	80.70	74.20	63.60	76.90	93.20	68.20	60.50	70.50	72.30
Straw consumed for 100 lbs. gain, lbs.	54.80	50.30	43.20	52.40	63.80	46.30	41.30	47.90	49.20
Cost of food for 100 lbs. gain	\$14.10	\$12.37	\$10.94	\$12.79	\$12.96	\$11.97	\$10.61	\$11.50	\$12.11



Fig. 13.—No. 55, best gaining steer in Lot 7.



Fig. 14.—No. 53, poorest gaining steer in Lot 7.

TABLE 16.—*Record of each steer in Lot 8, December 11, 1913, to May 15, 1914.*
 Ration—Corn, alfalfa, silage, cottonseed cake, and straw.

Number of each steer.....	57	58	59	60	61	62	63	Av. of lot
First wt. of each steer, lbs.....	885.00	1,020.00	880.00	790.00	923.00	1,004.00	989.00	927.00
Final wt. of each steer, lbs.....	1,225.00	1,390.00	1,213.00	1,110.00	1,175.00	1,317.00	1,293.00	1,246.00
Total gain of each steer, lbs.....	340.00	370.00	333.00	320.00	252.00	313.00	304.00	319.00
Av. daily gain each steer, lbs.....	2.20	2.40	2.16	2.08	1.64	2.03	1.97	2.07
Av. amt. of corn consumed daily, lbs.....	17.30	17.80	15.48	15.64	16.97	17.02	15.50	16.50
Av. amt. of alfalfa consumed daily, lbs.....	.94	.98	.88	.78	.88	.95	.91	.90
Av. amt. of silage consumed daily, lbs.....	20.03	19.97	18.07	12.31	19.17	22.15	22.43	19.10
Av. amt. of cottonseed cake consumed daily, lbs.....	2.46	2.79	2.78	2.74	2.76	2.14	2.32	2.57
Av. amt. of straw consumed daily, lbs.....	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
Corn consumed for 100 lbs. gain, lbs.....	783.60	741.10	715.70	752.90	1,036.80	837.30	785.00	797.90
Alfalfa consumed for 100 lbs. gain, lbs.....	42.60	40.90	40.80	37.70	54.00	46.60	46.10	43.70
Silage consumed for 100 lbs. gain, lbs.....	907.60	831.40	835.90	592.50	1,171.20	1,089.90	1,136.20	925.10
Cottonseed cake consumed for 100 lbs. gain, lbs.....	111.70	116.50	128.60	131.70	168.60	105.20	117.50	124.10
Straw consumed for 100 lbs. gain, lbs.....	45.60	41.90	46.50	48.40	61.50	49.50	51.00	48.60
Cost of food for 100 lbs. gain.....	\$12.41	\$11.83	\$11.71	\$11.74	\$16.63	\$13.29	\$12.92	\$12.86



Fig. 15.—No. 58, best gaining steer in Lot 8.



Fig. 16.—No. 61, poorest gaining steer in Lot 8.

Steer No. 26 in Lot 4 made the largest gain of any steer in the test, while steer No. 30 in the same lot made the smallest gain. During the 154 days that the steers were on feed, No. 26 gained 166 pounds more than did No. 30. Furthermore, the cost of gains made by No. 26 was \$6 less per 100 pounds than the cost of gains made by No. 30. The average difference between the highest and lowest gaining steer in each of the eight lots was 121 pounds. Here, again, is demonstrated the important part that the individuality of an animal plays in the economy of meat production.

In studying the pictures of the best and the poorest gaining steers in each lot, usually a considerable dissimilarity may be noted. This is particularly true of Nos. 26 and 30. There is a wide difference between the smooth, deep, and blocky form of No. 26 and the rough and lanky appearance of No. 30. However, even a careful study of feeder cattle does not always reveal their feeding possibilities. This fact was well demonstrated by steers Nos. 41 and 45 in Lot 6. When the experiment was started No. 45 was picked as one of the best feeders in the lot and yet No. 45 gained over 100 pounds less than did No. 41. It will be noted that, of the two steers, No. 45 seems to have had more requisites for the good feeder type. The picture shows that this steer was not very deep thru the rear flank, but that he possessed a good middle and a larger heart girth than did No. 41. While depth thru the rear flank must be regarded as important in a feeder steer, yet in this case steer No. 41 did not appear to be sufficiently superior in flank depth to steer No. 45 to offset the other advantages in form which seemed to be possessed by No. 45.

If all the steers in the different lots had made their gains as cheaply as did the best steer in each of the lots, three of the lots, 2, 7, and 8, would still have been fed at a loss.

In comparing the feeding records of the steers in the 1912-13 experiment with the records of the steers in the 1913-14 experiment, it will be noted that while the average gain per lot was higher in the first test, nevertheless the steers in the second test show much more uniform gains. Two steers in the 1912-13 experiment made larger gains than the best steer in the 1913-14 experiment, while one steer in the 1912-13 experiment made less gains than the poorest steer in the 1913-14 experiment.

FINANCIAL TABLES.

The following tables show the costs of producing the 100 pounds gain in the different lots of both experiments with alfalfa hay and corn at various prices:

TABLE 17.—Cost of 100 lbs. gain in the 1912-1913 experiment with corn at 50, 55, 60, and 65 cents per bushel, other feed prices unchanged.

Corn	Lot 1	Lot 2	Lot 3	Lot 4	Lot 5	Lot 6
50 cents	\$10.81	\$10.30	\$10.37	\$8.74	\$9.40	\$8.29
55 cents	11.65	10.95	11.20	9.35	10.09	8.99
60 cents	12.50	11.61	12.03	9.96	10.79	9.69
65 cents	13.34	12.26	12.87	10.57	11.49	10.39

TABLE 18.—Cost of 100 lbs. gain in the 1912-1913 experiment with alfalfa at \$10, \$12, \$14, and \$16 per ton, other feed prices unchanged.

Alfalfa	Lot 1	Lot 2	Lot 3	Lot 4	Lot 5	Lot 6
\$10 per ton				\$8.01	\$8.61	\$7.56
\$12 per ton				8.23	8.91	7.89
\$14 per ton				8.46	9.22	8.23
\$16 per ton				8.69	9.52	8.57

TABLE 19.—*Cost of 100 lbs. gain in the 1913-1914 experiment with corn at 42, 50, 55, and 60 cents per bushel, other feed prices unchanged.*

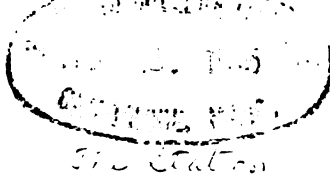
Corn	Lot 1	Lot 2	Lot 3	Lot 4	Lot 5	Lot 6	Lot 7	Lot 8
42 cents	\$7.54	\$8.54	\$7.99	\$8.49	\$8.54	\$8.24	\$8.97	\$9.49
50 cents	8.66	9.80	9.12	9.61	9.63	9.35	10.02	10.60
55 cents	9.38	10.61	9.85	10.33	10.33	10.06	10.69	11.32
60 cents	10.10	11.43	10.58	11.05	11.04	10.78	11.37	12.04

TABLE 20.—*Cost of 100 lbs. gain in the 1913-1914 experiment with alfalfa at \$8, \$12, \$14, and \$16 per ton, other feed prices unchanged.*

Alfalfa	Lot 1	Lot 2	Lot 3	Lot 4	Lot 5	Lot 6	Lot 7	Lot 8
\$8 per ton	\$10.52	\$11.91	\$11.10	\$11.58	\$11.58	\$11.32	\$11.87	\$12.72
\$12 per ton	11.12	12.56	11.52	11.95	11.89	11.65	12.21	12.80
\$14 per ton	11.42	12.89	11.73	12.13	12.04	11.81	12.38	12.85
\$16 per ton	11.71	13.22	11.94	12.32	12.19	11.97	12.56	12.89

Referring to the tables showing costs of gains with corn at different prices, it will be observed that had the corn used in the 1913-14 test been priced at 42 cents per bushel, as it was in the 1912-13 test, the cost of 100 pounds gain in all of the lots would have been reduced more than \$3. In this case Lot 1, fed a ration of corn and alfalfa hay, would have made its gains at a cost of \$7.54 per 100 pounds. This is but 32 cents more than the cost of 100 pounds gain on the steers in Lot 6 of the 1912-13 test, which were also fed a ration of corn and alfalfa hay. Had the alfalfa hay, used in the 1913-14 test, been valued at \$8 per ton (the valuation given alfalfa in the 1912-13 test) and had corn been valued at 42 cents per bushel, the cost of 100 pounds gain in Lot 1 of the 1913-14 test would have been \$7.24, or almost exactly the same as the cost of 100 pounds gain in Lot 6 of the previous test. On the other hand, if the corn used in the 1912-13 test had cost 65 cents per bushel and the alfalfa hay \$10 per ton, the gains in Lot 6, instead of costing \$7.22 per 100 pounds, would have cost \$10.73, or 9 cents less per 100 pounds than the cost of gains in Lot 1 of the 1913-14 test.

It will be noted that in both experiments the cost of gains on the steers was more than \$1 cheaper per 100 pounds when corn cost 42 cents per bushel than it was when corn cost 50 cents per bushel. In other words, an advance of 8 cents per bushel in the price of corn increased the cost of gains over \$1 per 100 pounds. Had the alfalfa hay used in the 1913-14 test cost \$16 per ton, the cost of 100 pounds gain in Lot 1 would have been \$11.71 instead of \$10.82, as it was with alfalfa hay at \$10 per ton. An increased cost of \$6 per ton for alfalfa hay increased the cost of 100 pounds gain 89 cents. In the same lot it will be noted that an increase of 5 cents per bushel in the price of corn increased the cost of 100 pounds gain 72 cents, that is, in this test an increase of 1 cent per bushel in the price of corn produced approximately the same effect as did an increase of \$1 per ton in the price of alfalfa hay.



Fries

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MANAGEMENT OF IRRIGATED LAND.

REPORT OF THE SCOTTSBLUFF EXPERIMENTAL SUBSTATION, MITCHELL,
NEBRASKA.

BY FRITZ KNORR, Superintendent.

JUNE, 1915.



IRRIGATION CROP ROTATION PLATS. SCOTTSBLUFF EXPERIMENTAL FARM.

LINCOLN, NEBRASKA
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* Resigned.

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SUMMARY.

Seepage may be prevented to some extent by employing proper methods of irrigation. Overirrigation may have a tendency to water-log the soil.

A small head of water, properly used, will irrigate more land and do better work than a large head gone over the land hurriedly.

The distance of irrigation ditches should be such that the water may travel between the ditches in about two hours.

If land can be irrigated in the fall with the same care that crops are irrigated in the summer, there is an advantage to fall irrigation. If water cannot be properly cared for and this irrigation is uneven, it is a detriment rather than a benefit to the land.

It is a disadvantage to ditch the potatoes as deep on the lighter soils as on the heavier soils.

With the exception of the first crop it is best to irrigate alfalfa after the hay is cut. Irrigation of the stubble is more easily and more evenly done than the standing crop. The hay will cure more quickly on the dry soil than on previously irrigated soil.

There is no material difference in the yields in sugar beets where the soil is plowed from 4 to 20 inches deep. This may be due to the fact that the soil is of a sandier nature. The plowing under of a second and third crop of alfalfa has not produced as large tonnage of sugar beets as the second and third crops that were plowed under.

MANAGEMENT OF IRRIGATED LAND.

BY FRITZ KNORR, SUPERINTENDENT.*

INTRODUCTION.

It is the ambition of most farmers to produce the largest possible yields of which the land is capable, provided that the cost of production allows a sufficient income to warrant the extra labor required to produce the larger yield. In the humid areas the increased yield is accomplished to a large extent by the use of manure and such other methods as will encourage plant growth. On the irrigated lands, many are trying to force increased yields by the increased use of water, rather than by other means.

Water, however, can never be made to take the place of soil fertility or cultivation. It appears from observation that to a certain point fertility may replace water. In other words, the more fertile soils utilize moisture more efficiently, with the proper treatment.

The heavier soils likewise require less irrigation water than the sandy soil. The lighter soils lose a large amount of water thru seepage, whereas it may be retained in a heavier soil.

SEEPAGE.

Nearly all irrigated lands are subjected to damage thru seepage to a greater or lesser extent upon certain low points or areas. This seepage is brought about by a number of conditions, some of which may be prevented or modified, but many cannot be avoided.

The unavoidable conditions are due to the various strata of

* The Scottsbluff Experiment Farm is located on the North Platte Reclamation Project, six miles east of Mitchell and eight miles northwest of Scottsbluff, Nebraska. The tract consists of 160 acres of land, irrigated from the Government canal. About 30 acres are devoted to experiments in dry land agriculture, and the remainder is irrigated, a wide variety of experiments being conducted with irrigated crops. The work of the farm is maintained cooperatively by the University of Nebraska and the U. S. Department of Agriculture, and is under the direction of a Superintendent detailed by the Office of Western Irrigation Agriculture, U. S. Department of Agriculture.

the subsoil that prevent the water from passing farther down but carry the water to some outcropping of these impervious strata, thus forming a seepage area. It has been found that in many cases large basins are formed by this impervious subsoil, and this also has a tendency to hold the water as seepage.

Some seepage may be prevented by better means and methods of irrigation. In all crop work under irrigation the first consideration should be to secure the best possible results from the least amount of water applied.

IRRIGATION.

To irrigate properly requires time and is a costly operation. By using an excessive amount of water the cost of the extra water, together with the labor of irrigation, does not always increase the crop sufficiently to justify the expense.

Many irrigators are under the impression that, as the amount of water applied to the crop is increased, in a like proportion the crop yield is increased. In other words, if 1 acre-foot of water will produce 25 bushels of wheat, 2 acre-feet should be capable of producing approximately 50 bushels. No grain crop will produce in the same ratio as the water is applied; in fact, water applied beyond a certain limit has a tendency to decrease the yield rather than to increase it.

IRRIGATION HEAD.

It is not necessarily true that, because a large amount of water is applied to a crop in one or two irrigations, the crop gets the benefit from all of the water thus put on the land at the point of turnout.

Two large losses of irrigation water must be taken into consideration—run-off and underground seepage. The run-off is always apparent and may be reduced to a minimum by the careful irrigator by always catching the run-off from one ditch in the other, the only waste being in the end runs and on the last land. This run-off loss is well taken care of by most of our farmers, but the seepage loss has not been called to the attention of the irrigator as forcibly as it should be, for the reason that it is a condition that is not easily detected.

STORING WATER IN THE SOIL.

Soil is capable of storing and holding only a certain amount of water. Inasmuch as roots of plants penetrate and feed on the soil to only a limited depth, all water in the soil that is above the water holding capacity of that soil is waste. It percolates to soil areas below the reach of the roots and is carried off, usually crop-

ping out at some place in the form of seepage. Furthermore, it is useless labor to saturate the soil to a greater depth than the plants are capable of feeding.

Knowledge of the subsoil is a great aid in a better understanding of the application of water. On the lighter soils where there is a sandy or gravelly subsoil, labor is wasted in trying to store very much moisture in such a soil; lighter and more frequent irrigation alone will solve that problem. On heavy soil, or a deep soil, water may be stored to advantage. If the lighter soil has a clay subsoil, water may also be stored, but a sandy subsoil cannot be used as a reservoir for storing soil water for future crop use.

DISTANCE APART OF IRRIGATION DITCHES.

Shorter runs of water, that is, placing the supply ditches closer together, will often overcome much of the trouble of underground loss. It is impossible to state a definite or even an approximate distance between field laterals, as it all depends upon the topography of the land and the nature of the soil.

This Substation has tried to establish a time factor to determine the distance between ditches. Here also difficulties are encountered that vary with the head of water used and upon the spread of the water at the turnout. Under ordinary conditions in western Nebraska a run from 1 hour and 30 minutes to 2 hours should constitute the distance between laterals.

Irrigators on sandy soil frequently try to force water thru rowed crops having runs from 40 to 60 rods long. Often it requires from 8 to 12 hours and sometimes much longer for water to go thru such rows. The waste of water thru underground seepage in such cases must be readily apparent even to the most unobserving irrigator. Even if the waste water factor be eliminated, the labor problem or waste of time in such cases is such as to make methods of this kind prohibitive.

DUTY OF WATER.

Much work has been done in determining the duty of water, that is, to determine how much water is required to grow a given crop and secure the best possible results. An irrigator cannot use this as a basis for growing and producing a crop, as the duty of water must vary with the climatic conditions. Determining the duty of water has been invaluable in proving that there is a decided limit to the amount of water which may profitably be applied to land, also in showing the bad effect of overirrigation on the crop. It would be folly for anyone to lay down a rule stating that a given amount of water should produce a certain crop yield,

or that irrigations should be applied so far apart or a certain number of irrigations be applied during the growing period.

The amount of water to use or the number of irrigations depends upon climatic conditions, the slope of the land, nature or texture of the soil and subsoil, variety of the crop, and last upon the stage of growth of the crop.

It does not follow that because a grain crop has produced a heavy growth of straw it will produce grain in proportion to that growth. It is more often true that by forcing an undue amount of growth the grain may be small and shrunken, because the stems and leaves require a large amount of moisture that the irrigator cannot always apply at that stage of the growth. On land partially subjected to seepage the grain is usually plump because the moisture is constant.

It is not necessarily true, as many believe, that the greatest economy of water and labor is in the use of a large head of water forced over the greatest possible area that this water will cover. On very sandy soils a large head may be required, even tho considerable washing may take place unless great care is taken. Very level land bears a large head of water, in fact requires it. The more rolling lands should be handled under small heads, anything from 1 to 1½ second feet; more often 1 foot is found the best amount.

A large head of water rushing over the land has a tendency to "slick" the soil, where the water passes over readily, and thus prevents the proper irrigation. With small heads the run-off need not be very large and can be better regulated.

Rowed crops should be carefully planned on rolling land, giving the rows just enough fall that the water may be carried along without causing any washing. Where water is permitted to rush thru the rows, proper irrigation cannot take place; the washing of the soil and the waste water secured under such conditions are a loss. If the land permits, a fall of 3 inches to 100 feet is a good slope to give the run, altho on the average soil 6 inches to 100 feet will not cause much washing, if care is taken in irrigation.

The conservation of soil moisture is just as essential under irrigation as under any other method of farming, perhaps more so, as the water itself represents value and its application expense.

A good system of crop rotation is a means of saving irrigation water. It also brings about a more equitable distribution of the irrigation season.

Alfalfa, as is well known, requires more water than any other crop. It is extremely difficult to irrigate evenly a large acreage

of alfalfa where the rotation delivery of water is practiced. Considering also that alfalfa, if sold off the farm at prevailing local prices, is a poor paying crop, it would be bad management to rely upon this one crop, if not used for feeding purposes on the farm where grown.

Seldom do sugar beets, potatoes, or corn require water early in the season when the small grain requires attention. About the time that the small grain is out of the way of irrigation the rowed crop will require water.

Where only alfalfa and small grain are grown the irrigation season is all crowded into one short period.

On the lighter soils with a sandy subsoil, it is impossible to irrigate in the hope of storing sufficient water to grow and mature a crop of any kind. Such a procedure, however, may be possible where there is a clay subsoil and the water may be held as in a basin. A sandy subsoil gives up its water and but a small amount is held in reserve for the plants.

Many of the crops, such as potatoes, sugar beets, and small grains, do not feed very deep. Even tho there may be enough moisture in the lower strata of the soil, it is of no value to the plants. Many irrigators consider a soil well irrigated if the full blade of the shovel may be pushed into the soil easily. Others dig a hole about a foot or more deep, and if the soil is thoroly saturated at that depth, the water is discontinued.

The latter method is more satisfactory; it will be found that where the shovel blade is used as a tester the soil is often wet much deeper than necessary. Tho the shovel may be pushed thru the very soft soil, just beneath this the soil may be almost saturated.

Several canvas dams are now on the market that by means of clocks and other devices can be set so as to collapse the dam at a certain time, permitting the water to go on down to a second dam, and so on. By the use of these dams much time as well as labor may be saved, especially during the night runs. Perfect irrigation cannot be expected from these dams, but with a very little trouble the uncovered spots may be gone over the following day. As a rule, 75 per cent of the irrigation water is lost during the night runs. This is a large item during the hot, dry weather, when the water is scarce. All end runs should be avoided during the night. It is best to start on a new land for a night run, thus making sure that the waste will not damage adjoining land.

FALL IRRIGATION OF CROPS.

Work has been conducted for three years to determine the

value of fall irrigation. The object was to store water in the soil and have the soil in better condition for field operations in the spring. As a rule the precipitation during the winter is very light, making it necessary at times to irrigate in the spring before some of the crops can be put into the soil to advantage.

Many are under the impression that the fall irrigation does not require the attention of general crop irrigation, that it is unnecessary to cover the ground as thoroly, and that to let it run as it will is sufficient. If one has not the time, however, to watch the water and irrigate thoroly, the work had better be left undone. If the ground is carelessly covered, some areas may be moist enough to germinate the grain quickly; on others it will have to lie in the soil until moisture comes to bring it up. This uneven growth will bring about an uneven maturity, hence a poor quality of grain. Some of the grain also may shatter long before a portion is ready to be cut.

One advantage of fall irrigation is that the soil has an opportunity to freeze and thaw during the winter, thus aiding in putting it in better tilth in the spring.

An objection to fall irrigation is the lack of time at that season of the year, and hence the careless manner in which the water is likely to be handled. The irrigation at this time of the year should receive just as much attention as tho a growing crop were on the ground.

Uneven application in the fall will make an uneven crop growth the following year. By allowing water to run where it will without any attention, or change, for a great length of time, is a waste of water. Such water is very likely to develop into seepage, either on that farm or lower down.

As previously stated, when the subsoil has been moistened to a certain depth, anything beyond that depth is waste, for grain crops. This depth is usually from 5 to 6 feet.

The first year's work in fall irrigation at this Substation did not include corn; this was added the second year. The crops were grown on one-tenth acre plats, either in duplicate or triplicate, depending upon the availability of the land. Table 1 shows the crops grown each year and the rotation that they followed, also the repetition of the crop each year.

TABLE 1.—Sequence of crops in the plats in Series VI and VII, used for the fall-irrigation experiments in 1911, 1912, and 1913.

Plat.No.	Year and crop			Plat.No.	Year and crop		
	1911	1912	1913		1911	1912	1913
1	Potatoes	Barley.		9	Oats	Barley ..	Beets
2	Wheat ..	Corn ...	Oats.	10	Potatoes	Oats ..	Potatoes.
3	Barley ..	Beets ...	Wheat.	11	Beets ..	Wheat ..	Corn.
4	Oats	Barley ..	Beets.*	12	Wheat ..	Potatoes	Oats.*
5	Potatoes	Wheat ..	Potatoes.	13	Oats	Beets ...	Wheat.*
6	Beets ...	Oats	Corn.	14	Potatoes	Barley ..	Beets.
7	Wheat ..	Corn ...	Oats.	15	Barley ..	Oats	Corn.*
8	Barley...	Beets ...	Wheat.	16	Beets ...	Wheat ..	Barley.

*These plats were used for a special experiment in 1913, and the yields of the crops are not considered in this report.

The land was broken out of the virgin sod during the fall of 1910 and irrigated after plowing. It was necessary to work down the land previous to irrigation. This required considerable useless labor. In succeeding years the land was irrigated before plowing.

The field designated as Series VI was irrigated in the fall. Series VII was not fall irrigated. During the growing seasons each field was irrigated in order as the various crops required it.

It was found without exception that the land that was irrigated in the fall did not require as early irrigation in the summer and thereby saved considerable labor at that time of the year. Thus, the expense of the late summer or fall irrigation was paid for.

The best results were obtained during the cropping season of 1911. This is attributed to the fact that there was a small amount of precipitation during the winter and spring. All soil was very dry at the time of seeding; in many cases irrigation was necessary before seeding could be done. That year the wheat was seeded April 4; the barley and oats were seeded April 20. It may be well perhaps to state here that untimely rains often interfere with irrigation experiments.

Series VI, which was fall irrigated, contained enough moisture to bring up all of the small grain, whereas the grain seeded on Series VII did not come thru the ground until after the rains of May 15.

The first irrigations applied to the small grain were June 12.

Series VI, which was fall irrigated, absorbed the water more readily, took up more water, and had less run-off than Series VII, which was not fall irrigated.

On June 27 the second irrigation was applied. At this time Series VI could have matured a good crop without any further irrigation, but for uniformity both fields were irrigated.

The yields of 1911 are given in Table 2.

TABLE 2.—*Comparison of yields, fall-irrigated land (Series VI) and nonfall-irrigated land (Series VII). 1911.*

Crop	Height, inches		Yield per acre				Pounds of straw per bushel of grain	
			Straw, pounds		Grain, bushels			
	<i>Series VI</i>	<i>Series VII</i>	<i>Series VI</i>	<i>Series VII</i>	<i>Series VI</i>	<i>Series VII</i>	<i>Series VI</i>	<i>Series VII</i>
Wheat	30	28	3,253	2,916	31.5	22.4	103.3	130.2
Barley	30	25	2,573	2,936	37.6	28.0	68.4	104.9
Oats	39	38	3,506	3,178	68.5	49.6	51.2	64.1

In every case there was more straw on the fall-irrigated land as a whole, but it required more straw growth to produce 1 bushel of grain on the land not fall irrigated.

WORK IN 1912.

On September 29 and 30, 1911, the land was irrigated preparatory for work in 1912. As soon as the soil was dry enough it was plowed about 7 inches deep and left in the rough until the following spring. In the fall of 1911 and the spring of 1912 the precipitation was 7.31 inches, as compared with 3.5 inches during the same period of the preceding year. This put all of the soil in splendid condition for spring seeding.

The wheat was seeded April 10, the barley and oats were seeded April 24, corn was planted May 8, sugar beets were seeded April 27, and Early Ohio potatoes were planted the second week in May. All of the crops came up nicely. Two irrigations were required to produce a crop of small grain, the corn received one irrigation, and the beets and potatoes three irrigations each.

The yields of the various crops are given in Table 3.

TABLE 3.—*Yields of various crops on fall-irrigated land (Series VI) and on land not fall-irrigated (Series VII). 1912.*

Crop	Height, inches		Yield per acre				Pounds of straw per bushel of grain	
			Straw, pounds		Grain, bushels			
	<i>Series VI</i>	<i>Series VII</i>	<i>Series VI</i>	<i>Series VII</i>	<i>Series VI</i>	<i>Series VII</i>	<i>Series VI</i>	<i>Series VII</i>
Wheat	40	37	3,236	3,140	41.6	38.4	77.8	81.8
Barley	37	36	1,586	1,020	42.8	35.0	37.1	29.1
Oats	42	42	4,170	3,216	94.6	81.8	44.1	39.3
Corn . . . . .	.....	.....	4,050*	3,875*	52.2	48.8	77.5	79.4
Beets . . . . .	.....	.....	.....	.....	12.2†	11.4†	.....	.....
Potatoes . . .	.....	.....	.....	.....	121.0	119.5	.....	.....

*Stover.

†Tons.

In 1912 there was not as much difference in the yield as in the previous year. It will also be noted that the relation of grain to straw is much smaller, and both the oats and barley showed more pounds of straw per bushel of grain on fall irrigation.

WORK IN 1913.

In the fall of 1912 the land was irrigated September 29-30, plowed as soon as the land was dry enough, and left rough during the winter to check blowing. In the spring of 1913 the soil was in fair shape for seeding. The precipitation during the fall and winter was such as to give sufficient moisture for spring seeding.

The soil preparation was the same as in previous years. Wheat was seeded April 4. Barley and oats were seeded April 24. The barley and wheat germinated much more quickly than the oats. The germination of the oats on the land that was not fall irrigated was very slow and the field was spotted until after a rain in early May.

Corn was planted May 19. Hot winds from July 7 to 12 slightly damaged the corn.

The yields of the various crops are given in Table 4.

TABLE 4.—Yields of seven crops on fall-irrigated land (Series VI) and on land not fall-irrigated (Series VII). 1913.

Crop	Height, inches		Yield per acre				Pounds of straw per bushel of grain	
			Straw, pounds		Grain, bushels			
	<i>Series VI</i>	<i>Series VII</i>	<i>Series VI</i>	<i>Series VII</i>	<i>Series VI</i>	<i>Series VII</i>	<i>Series VI</i>	<i>Series VII</i>
Wheat	37	37	1,695	1,630	26.9	22.8	63.0	71.5
Barley . . .	31	32	1,530	1,405	30.4	26.9	50.3	52.2
Oats	44	42	3,310	2,005	92.7	87.0	35.7	23.0
Corn			4,425*	3,570*	66.0	48.2	67.0*	74.1*
Potatoes					124.5	122.2		
Sugarbeets					11.4†	8.9†		

* Stover.

† Tons.

In 1913 it required more straw or stover for each bushel of grain produced with all crops except oats, but as in previous years all crops produced higher yields under fall irrigation.

Table 5 gives a summary for the three years of all crops grown.

TABLE 5.—Average and relative yields of six crops on fall-irrigated land (Series VI) and on land not fall-irrigated (Series VII).

Crop	No. of yrs.	Number of plats		Unit of yield	Average yield per acre			Relative yield per acre (per cent)		
		VI	VII		VI	VII	Gain by fall irrigation	VI	VII	Gain by fall irrigation
Wheat	3	8	8	Bushel	33.3	27.8	5.5	119	100	19
Barley . . .	3	8	8	Bushel	36.9	29.9	7.0	123	100	23
Oats	3	8	8	Bushel	83.8	72.8	11.0	115	100	15
Corn	2	4	4	Bushel	59.1	48.5	10.6	122	100	22
Sugarbeets	2	5	5	Ton	12.3	10.7	1.6	115	100	15
Potatoes . .	2	4	4	Bushel	124.5	122.2	2.3	102	100	2
All crops								116	100	16

The average increase of all crops was 16 per cent in favor of fall irrigation. Where the soil is very light it would not be advisable to do fall plowing, as too much blowing and drifting would occur.

IRRIGATING AND CULTIVATING POTATOES.

In 1912 an experiment was begun to determine if possible the best method of irrigating potatoes, taking also into consideration methods of cultivation, labor, and water requirement.

The usual practice has been deep cultivation and ditching; the cultivation is often from 5 to 8 inches deep, and when the potatoes are properly ditched the ridges are over 1 foot high. In common practice every row is irrigated thruout the season after irrigation once becomes necessary.

The method of applying water in the experiment has been:

First, to irrigate every row, keeping the soil moist and the plants in a growing condition.

Second, not to irrigate until the plants require water, then irrigate every row and irrigate according to common farm practice.

Third, irrigate every row, but permitting the plants to suffer between irrigations.

Fourth, to irrigate alternate rows at such times as the crop requires water. At the first irrigation every other row was skipped; at the second irrigation the skipped rows were irrigated and the previously irrigated rows omitted. This switching back and forth was continued thruout the irrigation season.

Fifth, to irrigate every other row thruout the season, that is, one set of alternate rows did not receive any irrigation whatever.

One of the objects sought in this work was to reduce the labor of irrigation and the use of water to the minimum. No definite results can be given from the three years' work, but some valuable data have been collected with special reference to irrigation.

In the three years' work it was found that it is unnecessary to cultivate and ditch as deep on light soil as on the heavy soil. The yield of marketable tubers has been in favor of the more shallow culture.

By shallow cultivation is meant the working of the soil from 3 to 4 inches; the ditching is about 8 inches deep. The depth of the ditching must vary with the fall of the land to a large extent. On the land where there is but little fall and the water moves slowly the ditches must be deeper; otherwise the water in the furrow may get too high on the ridge and submerge the tubers in water, a condition that is detrimental to the crop. Where the fall is such that the water moves freely, the shallow ditching will give the best results.

Untimely rains interfered with the methods of irrigation during 1912 and 1913. In 1914, however, the conditions for irrigation

experiments were most excellent, and the water movement in the soil could be observed to good advantage.

In the case of alternate and every-other-row irrigation it was thought enough water could be stored in the soil to carry the crop a longer time than where water was applied in every row. On alternate and every-other-row irrigation, only one-half as much irrigated surface was exposed for evaporation, but the amount of water required was not affected by this; on the contrary more water was required.

The water for irrigation was run thru 1-inch iron pipes sunk into the soil at the head of each row. By this means the water could be well regulated, and the approximate time of running with an equal head gave the comparative amounts of water used.

Under the usual method it required approximately 2 hours and 30 minutes for the water to run thru rows 264 feet long and thoroly irrigate them; where water was run in alternate rows it required 5 hours running, and then the soil was not in as good condition as where every row was irrigated.

Considering the time of running, approximately the same amount of water was used in every instance, but in the alternate and the every-other-row irrigations the run-off was very large, causing much waste of water. The lateral or side movement of the water being very small, a deeper saturation was secured and a large amount of this no doubt was lost as underground seepage, and was too deep to be of any value to the potato crop.

On plats where the soil was kept moist thruout the season and the plants in a growing condition it required only about one hour for the water to run thru the rows. It is unnecessary to wet the soil more than three feet deep for potatoes. By keeping the soil moist is not meant keeping it saturated; a continuously wet, soggy soil saturated to its greatest possible depth is perhaps the worst condition that can be created for this crop. A mass of unprolific vines is usually the result from too much water.

In the irrigation no allowance was made for the deep and shallow cultivation, but in every instance it was found that those rows which were ditched deep were not as well watered as the shallow ditched rows. This was due to the fact that the downward movement of the water is much greater than the lateral movement. Hence, the roots did not benefit so much from the water; only a small portion of the main root system came in contact with the water.

TABLE 6.—Yields of potatoes under the various methods of irrigation.

Method	Bushels per acre	Rank of marketable tubers	Rank per cent culls
Irrigated every other row	215	5	5
Irrigated usual method.....	270	2	2
Irrigated alternate rows.....	239	4	4
Plants allowed to suffer between irrigations ...	234	3	3
Soil kept moist and plants growing.....	296	1	1

It will be noticed that the rank of marketable tubers and culls is the same thruout. It was found that whenever the growth of the potatoes was checked, second growth began on the tubers, making them very uneven and "knobby," many of them having to be thrown out with the culls.

ALFALFA.

Alfalfa is one of the leading crops, tho it is far from being a profitable crop, if only the hay is sold as such upon the market. Where the hay is fed to live stock and the alfalfa stubble is turned under every four or five years, then alfalfa becomes a profitable crop. One of the greatest values of alfalfa is the effect it has on other crops after it is plowed under; the fertilizing value of it is greater than manure when the latter is applied at the rate of 12 tons per acre.

The United States Reclamation Service has collected some very valuable data on the North Platte Project relative to the value of alfalfa stubble when turned under.

TABLE 7.—*Shows a comparison of yields on alfalfa ground and ground that has not been in alfalfa.*

Crops	Area acres	Unit yield	Yield per acre	Value per acre	Increased value of crop
Barley*	808	Bushels	36	\$21.72	\$12.02
Barley†	1,454	Bushels	16	9.70	
Corn*	510	Bushels	31	23.60	13.10
Corn†	5,514	Bushels	14	10.50	
Oats*	425	Bushels	39	15.75	7.90
Oats†	6,592	Bushels	19	7.85	
Potatoes*	525	Bushels	220	77.25	50.84
Potatoes†	570	Bushels	75	26.41	
Rye*	15	Bushels	6	4.67	.82
Rye†	230	Bushels	5	3.85	
Stock beets*	206	Tons	16	63.36	31.81
Stock beets†	9	Tons	8	31.55	
Sugar beets*	4,014	Tons	11	60.80	14.93
Sugar beets†	1,069	Tons	8	45.87	
Wheat*	55	Bushels	34	28.60	16.10
Wheat†	433	Bushels	16	12.50	

* Alfalfa stubble plowed under.

† Land that has not been in alfalfa.

The foregoing data were collected by the United States Reclamation Service on the North Platte Project in 1914. The figures were taken from a compilation made by Mr. Paul Rothi from the annual census taken on Reclamation Projects.

In many cases the crop yields were increased over 100 per cent by plowing under alfalfa stubble.

SEEDING ALFALFA.

Many farmers dislike to break up alfalfa, as some have experienced a little difficulty in securing a good stand. Some time has been devoted to methods of seeding alfalfa. As with other crops, no hard and fast rules can be laid down for this; much depends upon the soil conditions. Three methods have been followed, all of them more or less successful.

Spring seeding without a nurse crop has some years given excellent results, and has produced one and sometimes two good cuttings the same season. The objection to such seeding is that some years the weeds will get started at about the same time as the alfalfa, and it is necessary to clip these, thus entailing extra labor at a time of the year when it is not readily available.

The second method is the seeding of alfalfa with a nurse crop. In common practice this is the most popular method. The disad-

vantage of this is the failure of securing a good stand; uneven stands are very common. It often happens when the grain is almost ripe that the alfalfa should have water. The question then is whether one should take the chances of the grain lodging by an untimely irrigation or let the alfalfa take the chances of drouth. Another hardship on the young alfalfa comes after the nurse crop is cut. The young plants that have been growing in the shade of the grain are suddenly exposed to the hot sun; if the soil is moist there is no danger of the plants suffering very much. However, should the soil be very dry, then there is a great loss thru drying up of the small plants.

The third method that has been practiced very successfully for the past three years is stubble seeding. After the grain crop has been removed, the alfalfa is seeded into the stubble. This method of seeding permits the seeding of a full crop of grain instead of a lighter seeding, as required by a nurse crop. The soil, if too dry, should be irrigated previous to seeding, or, as on the sandier soils, it may be "irrigated up." The earlier this stubble seeding is done the better it is. The seeding may be done as late as August 25, and a good stand has been secured with a seeding as late as September 1, but such late seeding is not recommended.

Various methods have been tried for preparing the soil previous to seeding into the stubble. In the fall of 1913 one field was divided into three equal plats; No. 1 was double disked and harrowed before seeding; No. 2 was single disked and harrowed; No. 3 was seeded without any preparation whatever. All of the alfalfa was seeded with a disk drill, the seed running into the shoe and at the rate of 12 pounds per acre. There was no difference in the stand secured nor in the yield of hay cut during the following year.

In 1914 a good stand was again secured by seeding into the stubble without any preparation. This method, especially on the lighter soil, is to be recommended, as it will prevent blowing and drifting during the windy season, and the stubble will also have a tendency to hold the snow during the winter. The drill will do much better work in standing stubble than where it is worked down. The disk, unless very sharp, will not cut thru the straw if worked down.

IRRIGATING ALFALFA.

Experiments with (a) late summer and fall irrigation and (b) with early spring and late spring irrigations of alfalfa have resulted in no gain for one or the other. It is a common practice to irrigate alfalfa in the spring as soon as water is available. This

is usually at the beginning of the growing season, when the alfalfa requires a good irrigation.

Should the soil be very dry in the spring when growth begins it is well to irrigate. Alfalfa uses considerable water and suffers when irrigation is neglected. Many irrigators prefer to irrigate the crop just before cutting, believing that the water will injure the young growth and the crown if water is applied after the crop is removed. This, however, is not the case unless water is allowed to stand stagnant on the alfalfa.

The disadvantages of irrigating previous to cutting are: (1) The labor of walking thru the crop and tramping it down; (2) uneven spreading of water. Skips cannot be detected, the operation requires more labor, and after the crop is cut the hay will not cure as rapidly on the moist soil as where the land is dry. One of the advantages often mentioned for irrigating previous to cutting is more often a detriment. The contention is that the stubble will start the new growth more quickly if there is an abundance of moisture in the soil. If such a growth is too rapid it often seriously interferes with the hay on the ground; the new shoots growing under the haycocks even to the extent of growing into the hay.

CUTTING ALFALFA.

The time of cutting alfalfa makes no material difference as to the total yield obtained during the year, provided the irrigation has been normal. Tests have shown that three cuttings will produce just as much hay as four cuttings, provided the last cutting is made at the same time in both cases.

Cuttings made at different times to determine if the yield may be increased gave the following results:

TABLE 8.—*Results of alfalfa cuttings made at different times to determine if the yield may be increased.*

Yield	Date cut		
	June 23 July 26 Aug. 29 Sept. 18	July 2 Aug. 7 Sept. 18	July 12 Aug. 20 Sept. 18
1st cutting	1.22	1.89	2.70
2d cutting	1.74	1.94	2.05
3d cutting	1.85	1.45	.45
4th cutting	.53		
Total yield for season	5 34	5.28	5.20

The disadvantage of allowing the alfalfa to go too long before cutting is that it becomes very coarse; a better quality of hay is secured by the more frequent cutting. The difference in the food value of the hay cut at different times has not been determined, but experience has taught all feeders that the finer hay causes less waste in feeding, and more of it is consumed by the animals. This is sufficient cause for cutting it early and often. The quality of the hay should receive the first consideration.

SUGAR BEETS.

DEPTH OF PLOWING.

In 1912 work was started in an effort to determine the best depth of plowing for sugar beets. The depths plowed were 4, 8, 12, 16, and 20 inches. The first three depths were turned with a common sulky plow; the 16 and 20 inches were plowed 12 inches deep, and a subsoil plow was used to obtain the balance of the depth required.

The average yield for the three years is shown in Table 9.

TABLE 9.—Average yield of sugar beets for three years.

Year	Depth of plowing in inches				
	4	8	12	16	20
1912	20.5	15.4	17.1	18.7	16.4
1913	21.7	21.2	20.5	21.3	21.6
1914	14.6	14.0	14.8	14.7	14.4
Average.	18.9	16.8	17.4	18.2	17.4

The three years' results do not show any material difference for the various depths of plowing. It would, therefore, not be advisable under average farm conditions to turn alfalfa under as shallow as 4 inches, as the crowns cause too much trouble. Cultivation under such conditions is too slow and tedious, and good work cannot be done.

Results show, however, that plowing from 7 to 9 inches is all that is necessary for our soils, and if stubble ground is used for beets, even a shallower plowing on the lighter soils will produce equally good results.

PLOWING UNDER ALFALFA FOR SUGAR BEETS.

In the fall of 1913 and spring of 1914, work was carried on in connection with spring and fall plowing of alfalfa, also the turning under of the second and third crop of alfalfa in comparison

with alfalfa stubble. One year's results would indicate that there is but little difference when the plowing is done except in so far as the horse labor is concerned, and this must be taken into consideration. It was found that when the plants were in a growing condition and the roots full of sap the draft was much lighter than at that period when the roots were dormant.

TABLE 10.—*Results of plowing under alfalfa for sugar beets.*

Plat	Alfalfa plowed under	Yield per acre	Sugar	Purity
<i>Number</i>	<i>Crop</i>	<i>Tons</i>	<i>Per cent</i>	<i>Per cent</i>
3	Second	19.9	16.1	82.6
5	Third	17.2	17.3	87.1
7	Third	15.5	17.4	87.0
	Average	17.5	16.9	85.5

In this instance it would indicate that the second crop of alfalfa turned under produced 3.6 tons more sugar beets per acre than the average of Plats 5 and 7. This is offset by about 2 tons of alfalfa hay that the land would have produced in the second cutting, or 3.5 tons for both second and third cuttings. Where the third cutting was turned under, an average of 16.3 tons of beets was produced at the cost of the third cutting of hay, or 1.5 tons of hay.

At the same time this alfalfa was plowed under, adjoining plats were cut and the stubble plowed under, with the following results:

TABLE 11.—*Results of plowing under alfalfa stubble for sugar beets.*

Plat	Alfalfa cut before plowing compared with Table No. 9	Yield per acre	Sugar	Purity
<i>Number</i>	<i>Crop</i>	<i>Tons</i>	<i>Per cent</i>	<i>Per cent</i>
2	Second—stubble	20.6	14.3	82.6
4	Second—stubble	19.1	17.0	87.1
6	Third—stubble	18.5	17.0	87.2
8	Third—stubble	14.6	18.2	86.8
	Average	18.2	16.6	85.9

Comparing the two instances where the second crop was turned under and where only the second crop stubble was plowed

under, there is only 0.1 of a ton of beets in favor of turning the alfalfa under, and this is at the expense of 2 tons of hay.

Between the third crop of alfalfa turned under and the stubble there is a difference of 0.3 of a ton of beets, at the expense of 1.5 tons of hay.

Taking the average of all plats, the yield is in favor of the stubble plowing, as the difference in all cases is very small.

Under fall plowing the land was crowned in the fall and also backset in the fall. Under fall crowning the crowning was done in the fall and the backsetting in the spring.

TABLE 12.—Results of fall plowing land for sugar beets.

Fall plowing Plat No.	Yield per acre
	<i>Tons</i>
2	20.6
3	19.9
4	19.1
5	17.2
6	18.5
7	15.5
8	14.6
9	17.3
10	16.7
Average	17.7

TABLE 13.—Yield of sugar beets on land fall crowned but spring plowed.

Plat No.	Yield per acre
	<i>Tons</i>
11	16.2
12	16.2
13	16.8
14	18.1
15	16.8
16	17.5
17	13.8
18	14.5
Average	16.2

TABLE 14.—Yield of sugar beets on land spring crowned and plowed.

Plat No.	Yield per acre	Plat No.	Yield per acre
	<i>Tons</i>		<i>Tons</i>
19	16.6	22	17.6
20	17.0		
21	18.5	Average	17.4

In all of the instances of plowing and of whatever method followed, the yield is not affected so long as the work is done well and the alfalfa crowns destroyed so as to prevent any volunteer growth as much as possible.

Where the planting of the beets followed the backsetting, as soon as it could possibly be done, the volunteer growth of the alfalfa could be kept down much better. Where the land was allowed to lie any great length of time before planting, the alfalfa came thru and made considerable growth before the beets were out of the ground. This causes considerable trouble in the cultivation.

DISTANCE OF SPACING SUGAR BEETS.

The distance of spacing beets has but little influence upon the yield until distances of rows 28 inches apart and beets 12 inches apart in the row are attained.

This work was conducted for two years, but as the stand of beets in 1912 was not perfect, due to climatic conditions, the results are not comparable, and only the 1913 results are given in Table 15.

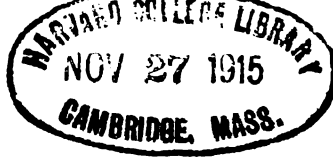
TABLE 15.—*Yield of sugar beets with various distances of spacing.*

Distance of rows	Distance plants apart in the row	Yield per acre
<i>Inches</i>	<i>Inches</i>	<i>Tons</i>
18	6	17.9
18	9	17.0
18	12	16.8
18	15	13.6
20	6	19.3
20	9	17.1
20	12	18.1
20	15	18.4
20	18	17.8
24	6	16.1
24	9	16.0
24	12	16.3
24	15	16.6
24	18	15.6
28	6	17.5
28	9	15.4
28	12	16.7
28	15	14.6
28	18	14.8

There was considerable difficulty in irrigating the beets that were 24 and 28 inches apart. As previously stated, the soil has but little capacity for carrying the water laterally. As the feeder roots of the beets are along the sides of the beet and do not seem to extend laterally very much, it was necessary to run the water too long to irrigate the crop properly. This was especially true where the rows had too much fall.

Several plats were planted with rows alternately 18 and 24 inches apart; this would make the rows 21 inches apart on the average. The object was to give more space to the horses in the rows and perhaps work the beets to better advantage.

Only the wide rows were to be ditched, but the same difficulty was encountered as in the wide planting, and in order to irrigate properly the narrow rows had to be ditched.



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LAMB FEEDING EXPERIMENTS.

- Part I. Fattening Western Lambs.**
Part II. Fattening Native Lambs.
Part III. A Comparison of Native and Western Lambs.

BY HOWARD J. GRAMLICH.

DISTRIBUTED OCTOBER 25, 1915.



LINCOLN, NEBRASKA
U. S. A.

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SUMMARY OF PART I.

1. The addition of corn silage to a ration of shelled corn and alfalfa hay increased the daily gain 0.005 pound per lamb and increased the cost of producing 100 pounds gain 4 cents but did not affect the net profit per lamb. (Table 1.)

2. With shelled corn at 60 cents per bushel and alfalfa hay at \$10 per ton, lambs on a heavy feed of shelled corn (approximately 1.5 pounds) and 1 pound of alfalfa made gains at a cost of \$5.11 per 100 pounds. (Table 1.)

3. Lambs on ground corn and ground alfalfa consumed 0.126 pound more corn and 0.093 less alfalfa daily than lambs on shelled corn and whole alfalfa hay. (Table 2.)

4. Lambs on ground corn and ground alfalfa made daily gains of 0.371 pound at a cost of \$6.12 per 100 pounds, while those on shelled corn and alfalfa hay made daily gains of 0.393 pound at a cost of \$5.11 per 100 pounds. (Table 2.)

5. Grinding corn and alfalfa and feeding the two mixed together did not produce sufficient added gain to offset the labor cost of grinding.

6. In a test to compare good versus poor quality alfalfa as a supplement to shelled corn in producing mutton, it was found that good alfalfa was worth double the value of the poor alfalfa. (Table 3.)

7. Lambs on good alfalfa and shelled corn gained 0.035 pound more per head daily and at a cost of 17 cents per 100 pounds less than lambs on poor alfalfa and shelled corn. (Table 3.)

8. Lambs fed good alfalfa consumed more roughness than those fed hay of poor quality. (Table 3.)

9. The addition of 0.726 pound corn silage daily to a ration of ground corn and ground alfalfa did not increase the daily gain but did reduce the cost of 100 pounds gain 31 cents. (Table 4.)

10. A ration of shelled corn, alfalfa, and silage produced 100 pounds gain at a cost of \$5.15, whereas a ration of ground corn, ground alfalfa, and silage produced 100 pounds gain at a cost of \$5.81, thus indicating that the whole grain and hay in conjunction with silage was the more economical of the two rations. (Table 5.)

11. Valuing corn at 60 cents per bushel, good alfalfa at \$8 per ton, and poor alfalfa at \$4 per ton in this experiment, 100 pounds gain on a ration of corn and good alfalfa cost \$4.88, and on corn and poor alfalfa, \$4.90. (Table 7.)

LAMB FEEDING EXPERIMENTS.

BY HOWARD J. GRAMLICH.

INTRODUCTION.

During recent years much interest has developed in the fattening of lambs on Nebraska farms. For years this State has ranked as one of the foremost among those which furnish fat lambs for the markets of the country. However, in the past the feeding has been done mostly by speculators who have owned or rented yards at convenient points and shipped in lambs by the train load direct from the western ranges. These lambs were billed direct to the markets with the privilege of feeding in transit at any given feed yard. This method of feeding, however, has largely been superseded by the one-car feeder who purchases his lambs at the market and fattens them on feed raised upon his farm, thereby utilizing much cheap roughness which would be difficult to dispose of otherwise.

PART I. FATTENING WESTERN LAMBS.

OBJECT.

The purpose of this experiment was to secure experimental data regarding the comparative values of corn and alfalfa hay fed in various forms both with and without corn silage. It compared a ration containing good alfalfa hay for roughage with one containing a poor grade of hay, likewise a ration of corn and good alfalfa with one of the same feeds plus corn silage. A ration of shelled corn and alfalfa hay was compared with one in which both the hay and corn were ground. A ration of ground corn and ground alfalfa was compared with one of the same feeds with corn silage added.

DESCRIPTION OF THE LAMBS.

The lambs used in this experiment were purchased on the Omaha market, October 28, 1914. They were of average quality and weighed 52 pounds. The cost price was \$6.65 per 100 pounds, whereas top feeder lambs brought \$7 per 100 pounds the same day.

They had been shipped from Wyoming, and judging by their appearance one would say they contained a little blood of some mutton breed crossed on a strong Merino foundation. There were 260 head purchased, this being 10 more than were placed on experiment, the desire being to have five lots of 50 each and have them as nearly uniform as possible at the opening of the experiment. Five died prior to the experiment, and the other five were sold later and credited in the financial statement.

TREATMENT PREVIOUS TO THE EXPERIMENT.

The lambs were dipped at the stockyards, following their purchase, and were received at the University Farm, October 29. They were placed in a two-acre dry lot and remained there for nearly three weeks. The first few days, alfalfa was the only feed given. This was scattered on the ground, and the lambs ate it heartily from the start. Later, a little shelled corn and silage was fed in the same manner. The corn was eaten quite readily. However, they seemed to care but little for the silage and greatly preferred alfalfa. As the weather continued dry thruout this period, there was but very little grain or hay wasted as a result of feeding on the ground. A week previous to the opening of the experiment, the lambs were divided and placed in their respective pens. The corn was then increased quite

rapidly so that November 26, when the test began, a daily average of 1 pound per head was being consumed. The corn fed thru this preliminary period amounted to an average of a quarter of a pound per head daily, and this as well as all other feed given at this time was charged to the lambs.

RATIONS FED.

The following rations were fed:

Lot 1.—Ground corn, ground alfalfa, and corn silage.

Lot 2.—Ground corn and ground alfalfa.

Lot 3.—Shelled corn and good alfalfa hay.

Lot 4.—Shelled corn, good alfalfa hay, and corn silage.

Lot 5.—Shelled corn and poor alfalfa hay.

FEED YARDS AND EQUIPMENT.

The yards where this experiment was carried on are located on a gentle, southwest slope. A four-panel board fence was constructed around the outside with the exception of the north where a 58-inch woven wire fence had previously been placed. Three-board partitions were used to divide the lots. Each one was 16 feet wide by 80 feet long. Thus, there were 1,280 square feet in each lot, or 25.6 square feet per lamb.

No provision was made for shelter other than to rick some corn fodder for a windbreak along the woven wire fence bordering the lots on the north. As most sheep are fed in the open in this State, it was considered that this test would be of more actual value to feeders if carried on under similar conditions.

Water was supplied in galvanized-iron troughs, and a fresh supply was kept before the lambs during each day. The troughs were emptied each night to prevent freezing.

Lots 1 and 2, which were on ground feed, received their rations mixed in feed troughs. These troughs were made as follows: The floor of each consisted of a 1-inch board 12 inches wide and 16 feet long. Four-inch fence boards were used for sides and ends. Inverted V's were made of 2-by-4-inch material and placed at either end and in the middle of each trough. Crosspieces were put across these 14 inches from the ground and the box placed thereon. A 1-by-6-inch fence board was placed along the top of the V's to prevent the lambs getting into the box. Two such boxes were placed in each of the five lots. Lots 3 and 5 received their corn in these, while Lot 4 also received silage therein. These three lots were each equipped with a 32-foot hayrack for feeding the alfalfa.

WEATHER CONDITIONS.

As these lambs were fed with no shelter other than a wind-break on the north, it would be but fair to give a brief statement of weather conditions during the experimental period, namely, November 26, 1914, to January 31, 1915.

In December the rainfall amounted to 0.91 inch, and the snow-fall, 7.2 inches. In January the snow which fell aggregated 23 inches. Thus during the experiment over 30 inches of snow fell besides rain amounting to nearly an inch. In December the mean temperature was 18.1 degrees and in January, 21.9 degrees. In each month there were six days when the mercury fell below zero.

That the lambs made so good a gain in spite of adverse weather conditions seems to indicate that sheep are adapted to withstand a good many unfavorable climatic conditions and still thrive. Another year a check lot will be fed in a lot with a shed to see what effect the protection will have on gains. Former experiments at this Station showed but little advantage from the sheds. However, the season naturally affects this factor a great deal.

The lambs went thru even the most severe weather and storms in the best of health, and there was no mortality during the period. Practically none of the lambs had colds, and they were always ready for their feed.

DURATION OF EXPERIMENT.

The experiment opened November 26, 1914, and closed January 31, 1915, a total of 65 days.

PRICES OF FEEDS.

At the opening of the experiment, corn was worth 50 cents per bushel. However, by the close it was up to 65 cents and had been as high as 70 cents for a few days between times. The average cost of the corn actually fed was 60 cents, and that is the price used. Baled alfalfa was purchased, and, while it cost \$10, the same hay on the farm where produced was actually worth from \$6 to \$7.50 in the stack. Consequently, the \$10 price is higher than the producer would figure it. The poor grade alfalfa cost \$7 and in the stack could have been secured for \$4 to \$4.50. However, alfalfa was unusually cheap during the fall of 1914 and the \$10 and \$7 prices used for the two grades would be very fair to cover a series of years.

Corn silage was valued at \$3.50 per ton, as this was ascertained to be the actual cost of it in the silo when the corn it con-

tained was valued at market price and added to the labor of harvesting the crop.

A charge of 3 cents per bushel was made for grinding the corn fed to Lots 1 and 2 and \$2 per ton for grinding the alfalfa fed the same lots. These figures were found to be fairly accurate and represent several records made to secure labor and other costs in connection with each operation.

CORN AND ALFALFA VS. CORN, ALFALFA, AND CORN SILAGE.

For several years, corn and alfalfa has comprised the fattening ration for sheep in most Nebraska feed yards. With the advent of the silo, much has been written relative to silage as a supplement to the above ration. With a view of ascertaining the effect of corn silage added to a corn and alfalfa ration, Lots 3 and 4 were fed as indicated above. Table 1 shows the result of this trial.

TABLE 1.—*Shelled corn and alfalfa hay vs. shelled corn, alfalfa hay, and silage.*

Lot.....	3	4
Ration.....	Shelled corn, whole alfalfa	Shelled corn, whole alfalfa, silage
Average initial weight, lbs.....	53.32	53.14
Average final weight, lbs.....	78.91	78.98
Average gain per lamb, lbs.....	25.59	25.84
Average daily gain, lb.....	.393	.398
Average daily ration {	corn.....	1.444
	alfalfa.....	.938
	silage.....	.473
Feed per 100 lbs. gain {	corn.....	366.84
	alfalfa.....	238.22
	silage.....	120.58
Cost of 100 lbs. gain.....	\$5.11	\$5.15
Average weight per head at Omaha, lbs.....	75.91	75.98
Net selling price per 100 lbs. at Lincoln.....	\$8.38	\$8.38
Average selling price per head at \$8.38 per 100 lbs.....	6.36	6.37
Average cost of feed per head.....	1.31	1.33
Average cost per head at beginning of experi- ment.....	3.95	3.94
Cost of lamb and feed.....	5.26	5.27
Average profit per head.....	1.10	1.10

By referring to Table 1 we see that Lot 4, which is the lot that received the silage, made a slightly larger gain. The corn consumed was practically the same in each lot. However, the lambs in Lot 3 consumed 0.94 pound alfalfa daily, while those

in Lot 4 ate only 0.81 pound but took in addition 0.47 pound corn silage. Thus the total dry matter consumed was practically the same. One hundred pounds of gain on Lot 3 cost but \$5.11 and on Lot 4, \$5.15. At the prices which these feeds cost, no advantage was gained from the use of silage. It should be said that the lambs in Lot 4 seemed to possess a dislike for the silage and failed to relish it as they should.

SHELLED CORN AND WHOLE ALFALFA VS. GROUND CORN AND GROUND ALFALFA.

It has always been the contention that sheep could grind their feed much cheaper than man could do it for them. Despite this, there are a number of feeders who have equipped their plants with grinding outfits and are fattening sheep on a mixture of ground corn and ground alfalfa. By grinding both materials and feeding them mixed together, it is believed that the mass is more penetrable to the digestive juices in the alimentary tract than where the grain is consumed before the hay. Also, it is popular opinion that animals will consume more feed where fed the mixture, and do proportionately better. With a view of testing these beliefs, Lot 2 was put on a ration of ground corn and ground alfalfa in order to secure a direct comparison with Lot 3, on shelled corn and alfalfa hay. The results appear in Table 2.

TABLE 2.—*Shelled corn and alfalfa hay vs. ground corn and ground alfalfa hay.*

Lot.....	3	2
Ration.....	Shelled corn, whole alfalfa	Ground corn, ground alfalfa
Average initial weight, lbs.....	53.32	53.26
Average final weight, lbs.....	78.91	77.41
Average gain per lamb, lbs.....	25.59	24.15
Average daily gain, lb.....	.393	.371
Average daily ration { corn.....	1.444	1.57
alfalfa.....	.938	.845
Feed per 100 lbs. gain { corn.....	366.84	422.68
alfalfa.....	238.22	227.41
Cost of 100 lbs. gain.....	\$5.11	\$6.12
Average weight per head at Omaha, lbs.....	75.91	74.41
Net selling price per 100 lbs., Lincoln.....	\$8.38	\$8.38
Average selling price per head at \$8.38 per 100 lbs.....	6.36	6.23
Average cost of feed per head.....	1.31	1.48
Average cost per head at beginning of experi- ment.....	3.95	3.95
Cost of lamb and feed.....	5.26	5.37
Average profit per head.....	1.10	.80

The lambs in Lot 2 went on feed quicker than those of Lot 3 and never failed to clean up their rations, altho they were given about all they cared for. To start with, they were fed 1 pound of corn and a like amount of alfalfa per day. The corn was increased and the alfalfa decreased so that by the end of three weeks they were consuming 1.6 pounds corn and 0.8 pound alfalfa daily. At the close of the experiment, their daily ration was 1.8 pounds corn and 0.88 pound alfalfa. Lot 3 did not eat quite so much corn. At the start the lambs were given 1 pound of both grain and hay daily, but at the end of the third week they were consuming only 1.4 pounds corn and 1 pound alfalfa. At the close, their ration consisted of 1.6 pounds corn and 1 pound alfalfa.

Considering the grain consumption in Lot 2 and the fact that none of the lambs went off feed, the gain made by this lot was not up to expectations. One hundred pounds of gain cost \$6.12 in Lot 2 as against \$5.11 in Lot 3. A charge of 3 cents per bushel for grinding the corn and \$2 per ton for grinding the hay was made against the feed consumed by Lot 2. Without charging Lot 2 for the grinding of the feed, their gains would still cost 56 cents per 100 pounds more than those made by Lot 3. The result of this test would tend to verify the belief that sheep do better and produce considerably cheaper gains on unground feed.

COMPARISON OF GOOD ALFALFA HAY AND POOR ALFALFA HAY WHEN FED IN CONJUNCTION WITH SHELLED CORN.

Every year the farmers of Nebraska have large quantities of off-colored, poor quality alfalfa hay. Generally this is the first cutting, and aside from being quite woody, it is often badly bleached and has lost many of its leaves. The Experiment Station receives numerous requests as to the feeding value of such hay. It is practically valueless on the city markets and as a rule is not worth in excess of 50 per cent of the price of good, green hay if sold upon the farm where produced.

In order to ascertain the value of such hay in fattening lambs, Lot 5 was placed on a ration consisting of shelled corn and some very typical first cutting alfalfa in order to compare with Lot 3 which received corn and green, leafy alfalfa of second and third cutting.

TABLE 3.—*Comparison of good alfalfa and poor alfalfa when fed with shelled corn.*

Lot.....	3	5
Ration.....	Shelled corn, good alfalfa	Shelled corn, 1st cutting alfalfa
Average initial weight, lbs.....	53.32	53.16
Average final weight, lbs.....	78.91	76.44
Gain per lamb, lbs.....	25.59	23.28
Daily gain, lb.....	.393	.358
Average daily ration { corn.....	1.444	1.472
alfalfa.....	.938	.901
Feed per 100 lbs. gain { corn.....	366.84	411.13
alfalfa.....	238.22	251.85
Cost of 100 lbs. gain.....	\$5.11	\$5.28
Average weight per head at Omaha, lbs.....	75.91	73.44
Net selling price per 100 lbs., Lincoln.....	\$8.38	\$8.38
Average selling price per head at \$8.38 per 100 lbs.....	6.36	6.15
Average cost of feed per head.....	1.31	1.23
Average cost per head at beginning of experi- ment.....	3.95	3.94
Cost of lamb and feed.....	5.26	5.17
Average profit per head.....	1.10	.98

By referring to Table 3, we see that the lambs in Lot 3 made an average gain of 2.31 pounds more than those in Lot 5 during the 65-day test. The daily corn consumption per lamb per day in Lot 5 was 0.03 greater than in Lot 3 while the hay consumption was 0.04 less. Hence, the total feed consumed per day was practically the same. The cost of 100 pounds gain in Lot 5 was \$5.28, while in Lot 3 it was but \$5.11. However, the poor hay was charged at \$7 per ton as against \$10 for the good hay. These figures were actual cost on the Lincoln market. If one were buying the hay it would pay well to buy the good hay at the prices mentioned. However, if a person had the poor hay on his farm and no other disposition for it, he certainly would not be warranted in discarding the poor hay and purchasing good hay even tho the above figures might seem to indicate such a procedure as economical. By referring to Table 7 where costs of gains with feeds at varying prices are given we find that when corn is figured at 60 cents per bushel, it cost \$4.90 to put on 100 pounds gain in Lot 5 with the alfalfa valued at \$4 per ton, \$5.15 where the alfalfa is valued at \$6, and \$5.41 where a valuation of \$8 is placed upon it. In Lot 3, we find that 100 pounds gain cost \$4.88 where the alfalfa is valued at \$8. Thus a ton of the

poor hay proved to be worth \$4 when the good hay was valued at \$8, or in other words just 50 per cent of the value of the good hay. With corn at 70 cents and good hay at \$10, 100 pounds gain in Lot 3 cost \$5.78, while allowing \$5 for the hay in Lot 5 with corn at 70 cents 100 pounds gain would cost \$5.67.

GROUND CORN AND GROUND ALFALFA WITH AND WITHOUT CORN SILAGE.

In order to ascertain the effect of adding silage to a ration of ground corn and ground alfalfa and thereby have results comparable with those sought where silage was added to shelled corn and whole alfalfa, Lots 1 and 2 were compared. The lambs in Lot 1 did not care for the silage and were inclined to muss over their feed and leave the larger pieces of silage. It was only by forcing that they were finally up to 1 pound per day by the close of the experiment. The lambs in Lot 4 took to the silage much more readily than did those in Lot 1. As to why this should be, it would be hard to assign a cause. The silage was of average quality and always fed fresh from the silo. It was placed in the troughs on top of the ground mixture of corn and alfalfa. Some

TABLE 4.—A ration of ground corn and ground alfalfa with and without corn silage.

Lot.....	2	1
Ration.....	Ground corn, ground alfalfa	Ground corn, ground alfalfa, silage
Average initial weight, lbs.....	53.26	53.14
Average final weight, lbs.....	77.41	77.27
Total gain per lamb, lbs.....	24.15	24.13
Daily gain, lb.....	.371	.371
Daily ration { corn.....	1.57	1.49
alfalfa.....	.845	.596
silage.....		.726
Feed per 100 lbs. gain { corn.....	422.68	400.57
alfalfa.....	227.41	160.55
silage.....		195.75
Cost of 100 lbs. gain.....	\$6.12	\$5.81
Average weight per head at Omaha, lbs.....	74.41	74.27
Net selling price per 100 lbs., Lincoln.....	\$8.38	\$8.38
Average selling price per head at \$8.38 per 100 lbs.....	6.23	6.22
Average cost of feed per head.....	1.48	1.40
Average cost per head at beginning of experi- ment.....	3.95	3.94
Cost of lamb and feed.....	5.43	5.34
Average profit per head.....	.80	.88

feeders in using this ration mix the three feeds together and permit it to stand from one feed to the next. Possibly the moistening of the ground feed in this manner would produce a beneficial effect upon the ration.

In both lots the average daily gain was 0.371 pound. However, owing to the heavy grain consumption and increased cost due to grinding, these two lots showed the highest cost per 100 pounds gain and consequently the lowest profit per head. In Lot 2, 100 pounds gain cost \$6.12, while in Lot 1 it cost \$5.81. Lot 2 averaged 1.57 pounds corn per day and 0.845 alfalfa while Lot 1 consumed 1.49 pounds corn, 0.596 pound alfalfa, and 0.726 pound silage. The addition of silage to this ration cheapened the cost of producing 100 pounds gain by 31 cents.

CORN SILAGE WHEN FED WITH SHELLED CORN AND WHOLE ALFALFA AND WHEN FED WITH GROUND CORN AND GROUND ALFALFA.

Lot 4, fed whole alfalfa and shelled corn with silage, made a daily gain 0.027 pound per lamb in excess of that made by Lot 1 on the ground feed and silage. Owing to the cost of feed preparation in Lot 1 and the lighter gains, we find that 100 pounds gain cost \$5.81 as against \$5.15 in Lot 4. The corn consumption was somewhat greater in Lot 1, while the alfalfa consumed amounted to only three-fourths as much as that consumed by Lot 4. On the other hand, Lot 4 consumed only two-thirds as much silage as Lot 1. Thus, the total feed per lamb per day in Lot 4 amounted to 2.739 pounds against 2.812 pounds in Lot 1, the dry matter being again practically identical in amount in each lot. This test seemed to favor the feeding of silage with shelled corn and whole alfalfa by a rather decisive margin.

TABLE 5.—*Comparison of corn silage when fed with a ration of shelled corn and whole alfalfa and when fed with ground corn and ground alfalfa.*

Lot.....	4	1
Ration.....	Shelled corn, whole alfalfa, silage	Ground corn, ground alfalfa, silage
Average initial weight, lbs.....	53.14	53.14
Average final weight, lbs.....	78.98	77.27
Average gain per lamb, lbs.....	25.84	24.13
Average daily gain, lb.....	.398	.371
Average daily ration { corn.....	1.453	1.49
alfalfa.....	.813	.596
silage.....	.473	.726
Feed per 100 lbs. gain { corn.....	365.67	400.57
alfalfa.....	204.70	160.55
silage.....	120.58	195.75
Cost of 100 lbs. gain.....	\$5.15	\$5.81
Average weight per head at Omaha, lbs.....	75.98	74.27
Net selling price per 100 lbs., Lincoln.....	\$8.38	\$8.38
Average selling price per head at \$8.38 per 100 lbs.....	6.37	6.22
Average cost of feed per head.....	1.33	1.40
Average cost per head at beginning of experi- ment.....	3.94	3.94
Cost of lamb and feed.....	5.27	5.34
Average profit per head.....	1.10	.88

TABLE 6.—*Summary of entire feeding trial with five lots of 50 lambs each.*

Lot.....	1	2	3	4	5
Ration.....	Ground corn, ground alfalfa, silage	Ground corn, ground alfalfa	Shelled corn, good alfalfa	Shelled corn, good alfalfa, silage	Shelled corn, poor alfalfa
Average initial weight, lbs.....	53.14	53.26	53.32	53.14	53.16
Average final weight, lbs.....	77.27	77.41	78.91	78.98	76.44
Average total gain, lbs.....	24.13	24.15	25.59	25.84	23.28
Average daily gain, lb.....	.371	.371	.393	.398	.358
Average daily ration, lbs. {	1.49	1.57	1.444	1.453	1.472
	.596	.845	.938	.813	.901
	.726	.....	.....	.473	.....
Feed per 100 lbs. gain... {	400.57	422.68	366.84	365.67	411.13
	160.55	227.41	238.22	204.70	251.85
	195.75	.....	.....	120.58	.....
Cost of 100 lbs. gain, c. 60c, c. s. \$3.50, alf. \$10, gr. alf. \$12, gr. c. 63c, p. alf. \$7.....	\$5.81	\$6.12	\$5.11	\$5.15	\$5.28
Net selling price per head at Lincoln.....	6.22	6.23	6.36	6.37	6.15
Average cost of feed per head.....	1.40	1.48	1.31	1.33	1.23
Cost of lamb and feed.....	5.34	5.43	5.26	5.27	5.17
Average profit per head.....	0.88	0.80	1.10	1.10	0.98

TABLE 7.—Cost of 100 pounds of gain with corn and alfalfa hay at varying prices.

Lot		50c				55c				60c				65c				70c				
			\$4	\$6	\$8	\$10	\$4	\$6	\$8	\$10	\$4	\$6	\$8	\$10	\$4	\$6	\$8	\$10	\$4	\$6	\$8	\$10
		Ration																				
1	Ground corn, ground alfalfa, silage	4.61	4.77	4.93	5.10	5.05	5.21	5.37	5.53	5.33	5.49	5.65	5.81	5.69	5.85	6.01	6.17	6.05	6.21	6.37	6.53	
2	Ground corn, ground alfalfa	4.68	4.91	5.14	5.36	5.14	5.36	5.59	5.82	5.44	5.66	5.89	6.12	5.81	6.04	6.27	6.50	6.19	6.42	6.65	6.88	
3	Shelled corn, good al- falfa	3.75	3.99	4.23	4.47	4.14	4.38	4.62	4.86	4.40	4.64	4.88	5.11	4.73	4.97	5.21	5.45	5.06	5.30	5.54	5.78	
4	Shelled corn, good al- falfa, silage	3.89	4.09	4.30	4.50	4.28	4.48	4.69	4.89	4.53	4.74	4.94	5.15	4.86	5.07	5.27	5.48	5.19	5.40	5.60	5.81	
5	Shelled corn, poor al- falfa	4.18	4.43	4.68	4.93	4.62	4.87	5.12	5.37	4.90	5.15	5.41	5.66	5.27	5.52	5.78	6.03	5.64	5.89	6.15	6.40	

¹ Above prices are on shelled corn and whole alfalfa hay. In Lots 1 and 2, the cost per 100 pounds gain includes customary charges for grinding both feeds, namely, 3 cents per bushel for corn and \$2 per ton for alfalfa.

**COST OF 100 POUNDS GAIN WITH CORN AND ALFALFA AT
VARYING PRICES.**

In Table 7 is given the cost of producing 100 pounds gain in the various lots where corn and alfalfa are charged at varying prices. These prices represent the approximate limits which have existed during the past several years for these two feeds on Nebraska farms. A careful study of this table will disclose some interesting and useful facts regarding the cost of producing gain with fluctuating prices of feeds. For instance, in Lot 3 with alfalfa at \$10 and corn at 50 cents, 100 pounds gain cost but \$4.47, while with hay at the same price and corn at 70 cents, the cost rises to \$5.78, or a difference of \$1.31. In Lot 5 with corn at 50 cents and alfalfa at \$10, the cost is \$4.93, and with corn at 70 cents and hay at \$10 the cost is \$6.40, or a spread of \$1.47.

With corn high and alfalfa cheap, the cheapest gains can undoubtedly be made by feeding a medium corn ration and heavy feed of alfalfa. Vice versa where corn is cheap and alfalfa very high. At the Illinois Agricultural Experiment Station¹ it was found that lambs consumed about the same amount of dry matter per day whether fed light, medium, or heavy rations of corn in conjunction with alfalfa hay. In other words, as the corn consumption increased, the hay consumption decreased in the same proportion and vice versa.

¹Illinois Bulletin 167.

Lamb Feeding Experiments.

19

FINANCIAL STATEMENT.

Purchasing expenses, October 28, 1914—

255 lambs, 13,328.65 lbs. at \$6.65 per		
100 lbs.	\$886.35	
Commission for buying	15.00	
Freight, Omaha to Lincoln	19.72	\$921.07

Feed consumed previous to experiment—

10,500 lbs. alfalfa hay at \$10	52.50	
1,312.5 lbs. corn at 60c	14.04	66.54

Feed consumed during experiment—

5,693 lbs. alfalfa hay at \$10	28.47	
4,683.25 lbs. alfalfa hay ground at \$12..	28.10	
14,186 lbs. corn, shelled, at 60c	151.98	
9,937.75 lbs. ground corn at 63c	111.80	
2,931.25 lbs. poor alfalfa hay at \$7	10.26	
3,919.25 lbs. silage at \$3.50	6.86	337.47

Selling expenses, February 1, 1915—

Freight, Lincoln to Omaha	27.10	
Yardage	13.55	
Insurance	.20	
Commission	25.00	65.85

Interest—

\$921.07 at 8 per cent for 90 days	18.42
--	-------

Receipts—

247 lambs, wt. 18,390 lbs., sold at Omaha		
at \$8.75 per 100 lbs.		\$1,609.12
3 slipped-wool lambs, wt. 210 lbs. at		
\$7.25		15.22

Net profit	214.99
------------------	--------

<u>1,624.34</u>	<u>1,624.34</u>
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PART II. FATTENING NATIVE LAMBS.

This experiment was conducted during the same months that the one described in Part I was in operation.

The object in this experiment was to test common rations on native lambs to ascertain the cost of producing gains on each. Lot 1, on corn and alfalfa, was compared with Lot 2, fed the same feeds with silage added, and also with Lot 3, on ground corn and ground alfalfa. Lot 4 was fed shelled corn, oil meal, and prairie hay, a ration which is used by many feeders who purchase all of their feed. As three of the lots in this experiment were fed on the same rations as three lots of the western lambs a comparison of economy of gains between the two kinds of sheep is given in Part III of this bulletin.

DESCRIPTION OF THE LAMBS.

The lambs used in this test were produced on the University Farm and were all either pure-breds or crosses between pure-bred animals of two different breeds. There were 28 head used in the test. They were divided into four groups of seven each. In each lot were 2 Shropshires, 2 Hampshires, 1 cross-bred Merino-Shropshire, 1 cross-bred Cotswold-Shropshire and 1 cross-bred Leicester-Shropshire. They were nine months old when the experiment began and weighed a trifle over 91 pounds. They had been fed a corn silage and alfalfa hay ration with a medium feed of corn and oats mixed, up to the opening of the experiment. They were in a good, thrifty condition but not fat.

EQUIPMENT.

The shed used for the experiment was of frame construction and had windows on the north, south, and west sides. These were kept partially opened thruout the entire test. Panel partitions divided the shed into four oblong pens, each 12 by 22 feet in size, thus providing 38 square feet per lamb. Water was supplied in galvanized-iron troughs, while grain was fed in low boxes along the edge of each pen. Hayracks were provided with tight bottoms and vertical slats 4 inches apart. As bedding became wet, more straw was added, the desire being to keep the pens as dry as possible.

PLAN OF EXPERIMENT.

Feeding was done regularly at 7 a. m. and 5 p. m. As the desire was to put on maximum gains in a short period, a heavy grain ration was fed from the start.

The rations fed were as follows:

- Lot 1.—Corn and alfalfa hay.
- Lot 2.—Corn, alfalfa hay, and corn silage.
- Lot 3.—Ground corn and ground alfalfa.
- Lot 4.—Corn, oil meal, and prairie hay.

Lots 1, 2, and 3 were started on a daily ration of 2 pounds corn and 1 pound alfalfa supplemented in Lot 2 with 1 pound silage. Lot 4 started on 2 pounds corn, 1 pound oil meal, and 1 pound prairie hay. However, the lambs did not care for the prairie hay, and it was later reduced to what they would consume. Likewise they were unable to handle 2 pounds of corn every day, as the average daily ration consumed will show. The plan was to divide the sheep evenly as to weight, quality, and breed, thereby making the only apparent difference one of rations fed.

DURATION OF EXPERIMENT.

The experiment opened on December 2, 1914, and closed January 30, 1915, a period of 59 days. Hence, it covered six days less time than the experiment with western lambs. As these lambs were under cover, the weather conditions during the experiment would not be of so much importance. Windows were left open even in the most severe weather in order to provide ample ventilation at all times.

FEEDS AND PRICES.

The following prices for feeds used in the experiment were considered as fair as could be determined for the period. They represent actual cost.

Shelled corn, per bushel.....	\$0.60
Ground alfalfa, per bushel.....	.63
Alfalfa, per ton.....	10.00
Ground alfalfa, per ton.....	12.00
Silage, per ton.....	3.50
Oil meal, per ton.....	35.00
Prairie hay, per ton.....	10.00

These are the same as those used in Part I, with prices on oil meal and prairie hay additional.

TABLE 8.—*Summary of 59-day experiment with native lambs.*

Lot.....	1	2	3	4
Ration.....	Corn, alfalfa	Corn, alfalfa, silage	Ground corn, ground alfalfa	Corn, oil meal, prairie hay
Average initial weight, lbs.	91.00	91.00	91.14	91.86
Average final weight, lbs.	127.43	121.86	120.00	121.14
Average total gain, lbs.	36.43	30.86	28.86	29.28
Average daily gain, lb.	.632	.523	.486	.496
Average daily ration—				
Corn	2.20	2.14	2.08	1.78
Alfalfa	.96	1.03	1.19	....
Silage .....	....	.62	....	....
Prairie hay .....	....	....	....	.56
Oil meal .....	....	....	....	1.01
Feed per 100 lbs. gain—				
Corn	348.04	408.53	425.00	357.63
Alfalfa	151.77	195.93	242.39	....
Silage .....	....	118.39	....	....
Prairie hay .....	....	....	....	112.46
Oil meal .....	....	....	....	204.19
Cost of 100 lbs. gain.....	\$4.48	\$5.56	\$6.24	\$6.96

By referring to Table 8, we find that Lot 1, fed shelled corn and alfalfa hay, produced 100 pounds gain at a cost of \$4.48, the cheapest; whereas gains on Lot 4, fed corn, oil meal, and prairie hay, cost \$6.96, the most expensive. Lot 1 gained daily per lamb 0.632 pound, the best; whereas in Lot 3, fed ground corn and ground alfalfa, the daily gain was 0.486, the least.

In Lot 1 we find a daily corn consumption per lamb of 2.20 pounds, the greatest; while in Lot 4 the corn consumption is only 1.78 pounds, but added to this is a daily consumption of 1.01 pounds oil meal.

Lot 2, fed corn, alfalfa, and silage, made gains at a cost of \$5.56 per 100 pounds, or \$1.08 greater than Lot 1, fed corn and alfalfa. This is rather surprising inasmuch as the lambs were all accustomed to silage prior to the experiment, and one would naturally expect Lot 2 to have shown up better as a consequence.

As in Part I of this bulletin, the lot on ground corn and ground alfalfa (Lot 4), consumed more corn than any other lot and made a relatively poor gain, indicating that grinding does not pay.

Lot 4 appeared to be doing very well thruout the experiment. However, the cost of producing gain was so great that the other lots all show better financially, altho daily gains were slightly greater in this lot than in Lot 3, fed ground feed.

FINANCIAL STATUS.

As these lambs were not purchased prior to the experiment it would be difficult to place an accurate valuation on them at the opening of the test. Likewise at the close, some of them were reserved for class use in the University School of Agriculture. Hence, their sale value was indefinite.

Twenty-one head were marketed in Omaha, February 1, which was the day the western lambs were sold. These brought \$8 per hundred pounds, whereas the westerns sold for \$8.75. The natives were classed and sold as yearlings on account of their extreme weight, altho the buyers were unable to discover any yearling teeth in their mouths. As the actual shipping and selling expenses on these lambs amounted to 32 cents per 100 pounds aside from the shrink in transit, it does not take much figuring to see that the finishing of them was unprofitable; they would have brought at least 7 cents at the time they went on test.

PART III. COMPARISON OF NATIVE LAMBS FED IN A SHED WITH WESTERN LAMBS FED IN AN OPEN LOT.

Inasmuch as the lambs in Part I were fed in open pens whereas those in Part II were fed in a shed, it is hardly fair to draw a comparison between the economy of gains with each and say the difference is entirely due to the lambs. However, Lots 1, 2, and 3 of the native lambs were fed on identical rations with Lots 3, 4, and 2 respectively of the western lambs. Hence, a comparison of daily food consumption and cost of gains should prove of interest. In each table there is only a very slight difference in the grain and roughness consumed per 100 pounds gain. The native lambs averaged approximately 91 pounds at the beginning as against 53 pounds for the western lambs.

TABLE 9.—*Comparison of western lambs fed in the open with native lambs which were shed fed.*

Ration, shelled corn and alfalfa hay.

	Westerns (Lot 3)	Natives (Lot 1)
Average initial weight, lbs.....	53.32	91.00
Average daily gain, lb.....	.393	.632
Average daily ration—		
Corn.....	1.444	2.20
Alfalfa.....	.938	.96
Feed per 100 pounds gain—		
Corn.....	366.84	348.04
Alfalfa.....	238.22	151.77
Cost of 100 pounds gain.....	\$5.11	\$4.48

In Table 9 we find a daily gain on the native lambs of 0.632 pound, whereas the western lambs gained only 0.393 pound. A portion of this difference may be ascribed to the greater size of the natives and consequent increased food consumption. While both consumed about the same amount of alfalfa daily, yet the corn consumption with the natives was 2.2 pounds as against 1.444 pounds with the westerns. This means that the westerns consumed only 66 per cent as much corn per day and gained 62 per cent as much in weight per day as did the natives. As the corn consumption and gain bear the same proportionate difference, we find the cost of 100 pounds gain to be very similar.

The natives were somewhat the more economical gainers, their cost of producing 100 pounds being just 88 per cent of that of the westerns.

TABLE 10.—*Comparison of western lambs fed in the open with native lambs which were shed fed.*

Ration, shelled corn, alfalfa, and silage.

	Westerns (Lot 4)	Natives (Lot 2)
Average initial weight, lbs.	53.14	91.00
Average daily gain, lb.	.398	.523
Average daily ration—		
Corn.	1.453	2.14
Alfalfa.	.813	1.03
Silage.	.473	.62
Feed per 100 lbs. gain—		
Corn.	365.67	408.53
Alfalfa.	204.70	195.93
Silage.	120.58	118.39
Cost of 100 lbs. gain.	\$5.15	\$5.56

In this comparison we find the westerns gaining 0.398 pound, a trifle more per day, and the natives gaining 0.523 pound, a trifle less than the lambs in Table 13. The addition of corn silage increased the cost of 100 pounds gain in both instances when we compare with the corn and alfalfa lots. The westerns produced 100 pounds gain at a cost of \$5.15, whereas the same gain cost \$5.56 on the natives. The natives consumed 43 pounds more corn to produce 100 pounds gain but a trifle less alfalfa and silage than the westerns. Inasmuch as the natives were thoroly accustomed to the silage prior to the experiment, it would be but natural to have expected them to make a better showing in this test than did the westerns. The westerns gained 76 per cent as much per day on 68 per cent as much corn, 79 per cent as much alfalfa, and 76 per cent as much silage as the natives received. As the westerns weighed at the opening of the experiment but 58 per cent as much as the natives, they made a higher proportionate gain in spite of poorer breeding and the lack of protection from storms.

TABLE 11.—*Comparison of western lambs fed in the open with native lambs which were shed fed.*

Ration, ground corn and ground alfalfa.

	Westerns (Lot 2)	Natives (Lot 3)
Average initial weight, lbs.....	53.26	91.14
Average daily gain, lb.....	.371	.486
Average daily ration—		
Ground corn.....	1.57	2.08
Ground alfalfa.....	.845	1.19
Feed per 100 lbs. gain—		
Ground corn.....	422.68	425.00
Ground alfalfa.....	227.41	242.39
Cost of 100 lbs. gain.....	\$6.12	\$6.24

In comparing these two lots, we find less spread between the daily gains than in the other groups. The natives gained only 0.486 pound daily while the westerns gained 0.371, or 77 per cent as much. The cost of producing 100 pounds gain, however, is practically the same, that of the natives being \$6.24 and of the westerns \$6.12. The reason for this must lie in the food consumption. The natives ate daily 2.08 pounds corn, while the westerns averaged 1.57 pounds, or 75 per cent as much. The natives consumed 1.19 pounds alfalfa per day and the westerns 0.845 pound, or 71 per cent of the former.

Summing up, we would have the westerns weighing 58 per cent as much as the natives at the start, gaining per day 77 per cent as much, on a ration amounting to 75 per cent as much corn and 71 per cent as much alfalfa, at a cost of 98 per cent of that for producing gain on the natives.

The corn consumed per 100 pounds gain was practically the same, being less than 0.5 per cent difference. The alfalfa consumed per 100 pounds gain was approximately the same, the westerns consuming a trifle less in producing 100 pounds gain, namely, 94 per cent that consumed by the natives.

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BULLETIN
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VOLUME XXVIII, ARTICLE II.

THE PRAIRIE DOG AND ITS CONTROL.

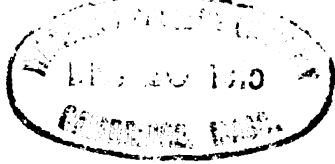
By M. H. SWENK.

DISTRIBUTED AUGUST 15, 1915.



A PRAIRIE DOG.

LINCOLN, NEBRASKA
U. S. A.



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THE PRAIRIE DOG AND ITS CONTROL.

BY M. H. SWENK.

INTRODUCTION.

About a century ago, as the early explorers crossed this western country, their attention was particularly drawn to numerous animals about the size of the ordinary cottontail rabbit which lived in colonies on the plains, and which when disturbed began a sharp and vigorous chattering or barking that often was continued after the approach of the observer had caused the animals to rush into their underground burrows. Lewis and Clarke appropriately dubbed this interesting animal the "barking squirrel," and later the naturalist Thomas Say called it the "Louisiana marmot," at the same time remarking that the name "prairie dog," which had been given to the animal "from a fancied resemblance of its warning cry to the hurried barking of a small dog," was inappropriate and absurd. Nevertheless, this real or fancied resemblance of the excited chatter of these animals to a dog's barking caused them to be generally called "prairie dogs," and this name has persisted over the possibly more correct ones, which have long since become obsolete.

This prairie dog of the plains is one of the most characteristic mammals of the dry, nearly treeless, interior country of the United States. From the eastern half of Montana and the southwestern part of North Dakota, it ranges southward thru eastern Wyoming and Colorado, western South Dakota, Nebraska and Kansas, most of Oklahoma and New Mexico, and western Texas into north-central Mexico. It is, apparently, confined to regions of dry, sunshiny climatic conditions. In the more western and mountainous States it occurs only at the lower elevations, that is, up to about 6,000 feet. Its present distribution in Nebraska includes practically the whole of the State west of the 98th meridian, tho over most of the extreme eastern part of this range its numbers are small and declining, being represented by only a few, scattered, weak colonies. Formerly prairie dogs occurred eastwardly nearly to the Missouri River. Up to about 1880 there used to be an 80-acre colony as far east as Plum Creek, near Beemer, in Cuming County, and another about one-half as large on Clark Creek, near Fontanelle, in Washington County, but these are now extirpated. As recently as 1902 the prairie

dog extended east along the Niobrara River to the point of its junction with the Missouri.

Proceeding westwardly in the State, however, the number of prairie dogs rapidly increases, and soon many large, strong colonies are to be found. Over at least one-half of the area of the State prairie dogs are abundant enough to be a distinct hindrance to agriculture, and in many localities the animals are important pests. Moreover, the evidence is conclusive that most of the colonies of these animals are rapidly increasing in extent and population, especially during recent years, wherever no determined effort has been made to reduce them. The accompanying map (fig. 1) shows the present distribution of the plains prairie dog in Nebraska, its approximate former distribution, and the general area and principal localities from which reports of injury have been received at the Agricultural Experiment Station during the past few years.

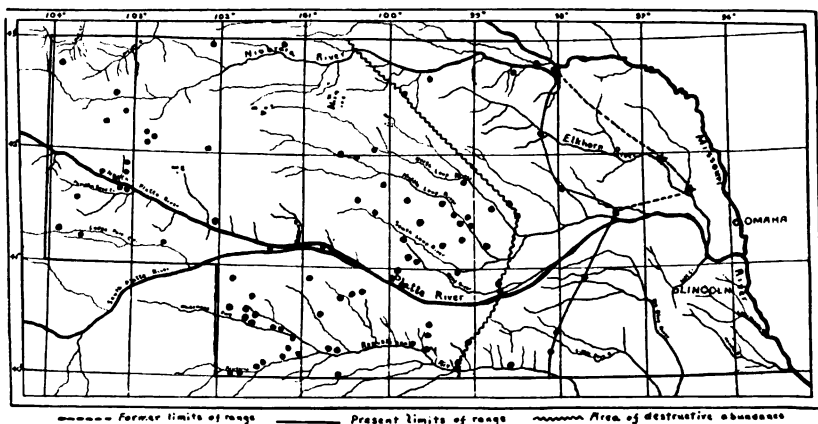


Fig. 1.—Distribution of the plains prairie dog in Nebraska.

INJURY.

The actual injury to Nebraska agriculture thru the ravages of prairie dogs has probably been underestimated, except perhaps by the men having large colonies of the animals on their ranches or farms. The chief damage by prairie dogs has been, and yet is, the extensive consuming or destroying of pasture grasses, especially in the valley lands of the ranges. But recently, with the increasing alfalfa acreage, the animals have come to quickly extend their colonies or establish new ones in alfalfa

fields, where their depredations soon become very serious and rival the injury to pastures. Moreover, because of the abundance of succulent green food supplied by the alfalfa plants, the prairie dogs are exceedingly difficult to destroy in such situations by the use of poisoned baits. Fields of wheat and other small grains, as well as fields of cane, kafir, and other sorghums, form attractive foraging grounds, and are to some extent utilized as places for the locating of colonies. If burrows are located in such fields the animals will clear a space for 10 or 12 feet around each burrow, thus destroying vastly more than they can actually consume. Prairie dogs are also proving something of a nuisance at places in the western irrigated districts by forming their burrows in the ditch banks, thereby sometimes causing washouts and making necessary the relocation of a ditch to stop water loss. Finally, the stepping into the open prairie dog burrows by horses and cattle has been the cause of many broken legs.

It is a very difficult matter to estimate, even approximately, the loss caused by prairie dogs in this State, owing to the scattered condition and variable size of their colonies, or "towns," and the varying density of their population, as well as the differences caused by contiguity or remoteness of the colonies in relation to cultivated fields. Colonies vary in size from a few dozen occupied burrows which cover an acre or two, to large colonies containing thousands of animals and covering several hundred acres. Nebraska colonies of size usually cover from 80 to 160 acres of pasture land, tho frequently as much as a half section is involved. In Texas, according to Merriam (5),* there is an enormous colony covering about 25,000 square miles.

As the area included in the "town" proper is usually kept largely or quite free from vegetation the value of the occupied areas as a foraging ground for live stock is largely lost. According to Merriam (5) on pasture lands 32 prairie dogs will eat as much as a sheep, and 256 as much as a cow, and the productive capacity of the invaded land is reduced from 50 to 75 per cent. Payne (8) in 1903 estimated that in eastern Colorado 2 per cent of the land was in dog "towns" and that this meant a loss of about 412 square miles of pasture land, or \$50,000 worth of forage. Lantz (6, 12) in 1903 and 1904 estimated on the basis of personal observations and reports from over 518 townships out of 1,015 infested townships, that two to two and one-half million acres of Kansas land were occupied by prairie dog "towns," mostly pasture lands on which the injury was about 50 per cent, making a loss of about \$80,000 to \$100,000 annually, and this not includ-

*Numbers in parentheses following authors' names refer to the bibliography at the end of the bulletin.

ing alfalfa and wheat lands or losses of these crops. Certainly the total loss in Nebraska cannot fall much short of this, and it would probably be conservative to estimate the annual loss thru prairie dog injury in this State at \$80,000.

APPEARANCE AND HISTORY.

The fully grown prairie dog of the plains (*Cynomys ludovicianus*) is a stout-bodied mammal about a foot in total length, with a short, full fur that in summer is a reddish brown above mixed with gray and black on the back and yellowish white below, and in winter is a grizzled buffy mixed with black above and pale buff below. The tail is short and flat, about three and a half inches long, and usually more or less black at the tip. The ears are very small, the cheeks have shallow pouches, or "pockets," the teeth are heavy and of the gnawing type, and the claws are long and well fitted for digging. The animal is really a specialized member of the squirrel family, most closely related to the woodchucks (*Marmota*) and ground squirrels (*Citellus*), and, needless to say, has nothing much in common with the dog.

The plains prairie dog was first scientifically named in 1815¹ from the plains of the upper Missouri, and two years later a special genus was formed for it.² Altho the plains prairie dog is the commonest and widest ranging species of the genus it is not the only one. In the higher parts of Colorado, New Mexico, and Arizona occurs the Gunnison prairie dog (*C. gunnisoni*), which is smaller and darker than the plains prairie dog, and which has a white-tipped tail. Farther west, in western Colorado, western Wyoming, and Utah, occurs the white-tailed prairie dog (*C. leucurus*), which has the tail two-thirds white and a black face patch. Four other species, *C. parvidens* from Utah, *C. arizonensis* from Arizona, *C. mexicanus* from northern Mexico, and *C. pyrrotrichus* from Oklahoma, are known. None of these, however, occur in Nebraska.

THE PRAIRIE DOG HOME.

Prairie dogs make their homes in burrows in the ground, the entrances of which are marked with circular mounds of earth from 3 or 4 to as much as 8 or 10 feet across and a foot or more in height, according to the length of the period of occupancy of

¹Ord, Guthrie's Geography, 2d Amer. ed., ii, pp. 292 and 302 (*Arctomys ludovicianus*).

²Rafinesque, Amer. Month. Mag., ii, p. 45 (*Cynomys*).

the burrow (fig. 2). The value of these high mounds seems to be to keep the water out of the burrows during the floods accompanying sudden and heavy rains (for unlike the pocket gopher's mound the entrances of the prairie dog burrows are kept fully open by the animals) and to serve as a vantage point to sit upon and observe the surroundings. These mounds rapidly narrow to the diameter of the burrow proper, which is 4 to 5 inches, thus forming a funnel-shaped crater in the top of each mound.



Fig. 2.—A prairie dog burrow. Haigler, Nebraska.

From time to time, as necessary, soil is scraped from just outside of the mound and the mound itself is repaired or enlarged, the animal pressing the dirt into position with its nose. In doing this the ground around each burrow is kept bare of vegetation, so that in crowded colonies the soil of the whole "town" is bare, smooth, and hard, and often remains free from vegetation for some years after the extermination of a colony. Only by persistent cultivation can such areas be quickly reclaimed.

The burrow proper first usually slopes at a moderate angle for about a foot and a half and then usually goes downward at a very steep angle, sometimes nearly straight down into the ground, for a depth of 12 to 16 feet. At the end of this vertical descent the burrow turns at right angles, continuing horizontally for several feet, and in ascending side extensions or in the end of this horizontal portion the nests of the animals may be found.

A burrow dug out by Mr. W. H. Osgood at Alma, Nebraska, and described by Merriam (5) went down nearly vertically for $14\frac{1}{2}$ feet, turned abruptly and then continued horizontally for $13\frac{1}{2}$ feet, the occupied nest being in an elevated lateral extension of this horizontal portion. The nests do not always thus drop vertically, however, as two dug out by Mr. J. T. Zimmer at Comstock, Nebraska, exemplify. One of these, dug out on November 1, 1913, was a mere winding burrow 5 inches in diameter which dropped 4 feet into the ground in a horizontal distance of $6\frac{1}{2}$ feet, the end ascending 10 inches in the terminal $2\frac{1}{2}$ feet of its length. This burrow had no pockets of any kind and the nest was in the elevated end. The total length of the burrow, in all of its windings, was $9\frac{1}{2}$ feet.

Another burrow, dug out December 3, 1913, was 4 inches in diameter and dropped obliquely 3 feet into the ground in a horizontal distance of 5 feet, then turned sharply to the left and enlarged to a diameter of 8 inches for about a foot when it narrowed again to the usual diameter and continued at the same angle for 11 feet before the terminal rise began. Undoubtedly the depth and form of prairie dog burrows varies greatly with different individuals, and probably also with the local soil conditions. Sometimes, also, a secondary burrow, which is often closed with soil, leads off from near the nest and reaches the surface at some distance from the main entrance mound, and these are usually used by the young prairie dogs until they are nearly grown.

HABITS.

The nest cavity in the burrow is heavily lined with buffalo grass and other fine grasses. Young prairie dogs appear but once a year, being born early in the spring, that is, late in March or early in April, and the normal number is said to be four. However, Mr. L. M. Gates saw an old prairie dog with six quarter grown young at a burrow near Haigler, May 19, 1914, indicating that the litter may sometimes exceed four in number. Other observers have given the maximum number at eight (8, 17). In May the young animals appear above ground and soon look after themselves. By the following spring they are fully grown.

Midsummer is utilized by the paired animals in the energetic digging of new burrows and in the cleaning out and repairing of the old ones. During the fall the animals become fat and quite sleepy. As cold weather approaches, during November, they decline in activity even more, and finally go into a partial hibernation within their burrows, tho they occasionally come out on fine, warm days even during midwinter. During the winter

the animals are usually to be found inhabiting burrows in groups of two to six pairs, probably for the conserving of warmth. With the growth of new vegetation in the spring they separate into single pairs to the burrow and resume their normal activity.

The periods of greatest activity in the prairie dog "town" are in the early morning and again in the evening. However, as a rule we have found very few dogs about before sunrise. During the hot part of the day they mostly stay in their burrows. Always a number of the animals may be seen standing erect on their burrow mounds, as sentinels to warn their feeding brethren of the approach of danger in any form. Whenever these sentinels give several sharp cries and disappear into their burrows with a characteristic flip of the tail, there is a general scurrying of the foraging animals to the protection of the burrows. They are able to live without drinking water, like some other mammals of arid regions, obtaining the necessary moisture for existence from the plants and seeds upon which they feed. The popular idea that the dogs dig to water is disproved by the fact that in some prairie dog towns artesian well borings have been sunk to a depth of hundreds of feet without striking water.

The prairie dog colony does not continually occupy the same limits but shifts more or less from year to year. As the animals do not have a wide foraging range, new burrows are continually extended toward areas of better food conditions in order to relieve the pressure of an increasing congestion of the population. Old burrows, too remote from the food supply, are eventually abandoned except as temporary places of refuge, and often considerable areas of the colony are thus left practically untenanted.

NATURAL ENEMIES.

In spite of the fact that prairie dogs do not wander far from their burrows, even when foraging, they are, naturally, greatly subject to control by natural enemies. And, aside from the favoring influence of increased food supply with the advent of cultivated fields, the chief reason for the recent increasing abundance of prairie dogs has been the removal of these enemies thru the activities of men, either directly or indirectly. In other words, it is the result of a constant and indiscriminating warfare waged by man against all carnivorous mammals and birds of prey.

Of course, some of this warfare is justifiable. The coyote (*Canis nebrascensis*) has too bad a record as a destroyer of live stock and poultry to be spared for the sake of the rather goodly number of prairie dogs that it stalks and destroys. The sharp-

shinned hawk (*Accipiter velox*), the Cooper hawk (*Accipiter cooperi*), and the western horned owl (*Bubo virginianus occidentalis*) have a bad record as destroyers of poultry, game, and song birds, and their destruction is good economic practice, even tho they may destroy a few prairie dogs. Nor would anyone advise the conservation of rattlesnakes (*Crotalus confluentus*), in spite of the fact that the chief food of these reptiles is young prairie dogs. But aside from these, all of the natural enemies of prairie dogs do so much more good than harm that they should be spared or protected, except possibly occasional individuals which have acquired bad habits.

Among the carnivorous mammals, both the long-tailed weasel (*Mustela longicauda*) and the black-footed ferret (*Mustela nigripes*) follow the prairie dogs relentlessly thru the most tortuous of their burrows until they catch and kill them. The badger (*Taxidea taxus*) feeds mostly on prairie dogs which it corners in their burrows and laboriously digs out and destroys. The northern plains skunk (*Mephitis hudsonica*), the long-tailed skunk (*Mephitis mesomelas varians*), and the prairie spotted skunk (*Spilogale interrupta*) are all highly important enemies of prairie dogs. All of these animals should be fully protected about prairie dog "towns."

Among the birds of prey, the ferruginous rough-legged hawk (*Archibuteo ferrugineus*) is found commonly about prairie dog "towns" and its food is largely, sometimes wholly, composed of these animals. The prairie falcon (*Falco mexicanus*), tho less common, is individually scarcely less valuable. The little burrowing owls (*Speotyto cunicularia hypogaea*) live in deserted prairie dog burrows and devour large numbers of the young dogs. The Krider and western red-tailed hawks (*Buteo borealis krideri* and *B. b. calurus*), the Swainson hawk (*Buteo swainsoni*), the marsh hawk (*Circus hudsonius*), and the short-eared owl (*Asio accipitrinus*) are all valuable destroyers of prairie dogs and should be protected instead of killed at every possible opportunity. The bull snakes about prairie dog towns, also, should never be killed, as they devour many of the young animals.

GENERAL CONTROL.

Considering, then, the generally obnoxious character of prairie dogs, when present in large and flourishing colonies and seriously injuring pastures and cultivated fields, it becomes an important and practical question as to how such aggressive colonies can be exterminated. Individual effort, tho helpful if sufficiently extensive, will not bring permanent relief if the rodents can restock

the colony by migrating in from other colonies in the vicinity. The organization of a general community warfare for a season or two is highly desirable, and will accomplish much more than many years of desultory and independent fighting. It is, in fact, essential for thoroly satisfactory results.

Two lines of attack on the prairie dog have suggested themselves as wholly feasible, and each has been rather fully investigated. These are, (a) the use of poisoned baits and (b) fumigating the burrows with asphyxiating gases.

USE OF POISONED BAITS.

In general, poisoned baits used against prairie dogs are one of two kinds: Freshly cut alfalfa or alfalfa hay poisoned and placed about the burrows, or else grain treated with some poisonous mixture. Tests of various deadly poisons by experimenters in the past have shown the general superiority, in safety of use, efficiency, stability, and economy, of strychnine (sulfate or alkaloid) as the poisonous element, and this was the only poison used in our experimental work. Powdered strychnine (not crystals) should always be used. Of course, in the preparation and handling of any strychnine-poisoned bait great care should be taken, since with the least carelessness serious results might come. However, most farmers and ranchmen fully realize the necessity of careful handling of strychnine and will take the necessary precautions. After preparing a batch of poisoned bait the utensils should be very thoroly cleaned. No residues of poisoned baits should be kept about the premises unless carefully guarded, labeled, and kept away from children. If, in spite of their small cost, it is preferred not to use poisoned baits, the carbon bisulfid treatment can always be resorted to.

The poisoned alfalfa bait is theoretically preferable to poisoned grain baits because it would not be attractive to small birds. Usually it is made by chopping about thirty pounds of the green plants into short lengths, and sprinkling until thoroly wet with a strychnine water prepared by dissolving an ounce of strychnia sulfate in a half gallon of boiling water, using a metal tub as a mixing vessel. If alfalfa hay is used, about 20 pounds of hay is required with the ounce of strychnine, which is dissolved in 3 or 4 gallons of water, the whole being thoroly mixed in the metal tub (15, 18).

In our experiments the use of alfalfa hay was wholly unsatisfactory. As an instance, 16 pounds of alfalfa hay was sprinkled with 5 gallons of water in which an ounce of strychnia sulfate had been dissolved, and this poisoned hay placed at prairie dog burrows at Comstock, Nebraska, November 19, 1912. When

these burrows were examined on November 21, there was no indication that the bait had been touched by the animals, and none had been killed, altho elsewhere poisoned grain was being readily taken at the same time and the animals were succumbing to it. Green alfalfa is procurable only at such seasons as green food is abundant and the dogs are difficult to poison with any bait whatever. Moreover, our observations showed that when poisoned grain is carefully applied the mortality to small birds is very slight. Consequently our efforts were directed mainly along the line of determining the best poisoned grain formula.

By using grain as a bait we have a food which the prairie dogs will take readily at any time that green food is not available. During the summer months when these animals feed almost wholly upon green food they are very difficult to poison, but after the grasses and roots have become dried and frozen they will take poisoned grain with alacrity. Therefore, for the beginning of poisoning operations late fall or early winter is the most propitious time, beginning usually in October or early November. The whole colony should be thoroly gone over at that time and usually a large percentage of the prairie dogs will be destroyed. The mere carrying of poisoned grain in the cheek pouches will kill the animals, even if they do not swallow any of it. A week or 10 days later a second application should be made to occupied burrows, and usually about one-half of the remaining animals will succumb to this treatment.

The operations had then best be suspended until the very early spring, when, if necessary, a third application should be made to occupied burrows. These two or three applications will destroy 75 to 90 per cent or more of the animals in the colony. The remaining animals can then be most thoroly and economically destroyed by fumigation. In mixing the grain and poison, the use of a galvanized fire shovel with five large holes drilled in it has been recommended (23). In distributing the poisoned grain the usual practice is to carry it in a sack and cover a strip 75 or 100 feet wide. A tablespoonful is usually placed about 18 inches from the mouth of each occupied burrow, and this was the amount used in our experiments, altho some use only one-half or even one-quarter of that amount (17). Of course, during the period that poisoned grain is about the burrows it is safest if live stock is excluded from that part of the range, altho it has been repeatedly used in pastures on which stock continued to graze without any fatalities. The grain can be dropped inside the burrow in the interests of perfect safety, but so much of it is lost by that method that the results are not nearly so satisfactory.

One cannot judge of the success of a poison application by the number of dead animals found within the colony, because the great majority of them die within their burrows and most of these that do die outside are carried away by coyotes within a few hours. Consequently one should not be discouraged because of a fewness of dead dogs to be found. Usually a little approximate census over portions of the colony a few days after the putting out of the poison as contrasted with a similar census taken before the application will reveal the true value of the treatment.

Peters and Avery (10) give the number of burrows per acre in a Nebraska prairie dog colony at 25 to 125, while Merriam (5) gives the number at Alma, Nebraska, as from 35 to 64. The average number over the whole of the large range pasture at Comstock, where our experiments were carried on, was a little over 30 to the acre, but in the more populous portion of the "town" it was 65 to 75 to the acre. Lantz (4, 6) states that in using poisoned grain at the rate of one tablespoonful to the burrow, a bushel will poison 1,000 to 1,200 burrows. This would be enough to cover 30 to 40 acres, on the average, if every burrow is treated, but as it is only necessary that the occupied burrows be treated that amount should cover 100 acres or more (100-160 acres according to Lantz). According to our experiments it requires a couple of hours to prepare the poisoned grain and a little over 20 hours of work for a man to carefully distribute a bushel of it to burrows determined as probably occupied. Valuing wheat at 85 cents a bushel, strychnine at 80 cents an ounce, and labor at \$2 a day, we find that it costs slightly over three-fourths of a cent to treat a burrow, and to treat every burrow in a "town" would cost from 19 to 25 cents an acre. But, as only the occupied burrows need be treated, even at the first application, the cost of an application is reduced to only 5 to 8 cents an acre. In other words, with a bushel or two of poisoned grain a couple of men can properly treat any ordinary prairie dog "town" in a day or two, at a cost for labor and materials of less than 10 cents an acre.

In order to determine the best manner to prepare the poisoned grain so as to obtain the maximum results in economy and efficiency, it was decided to test in competition with each other under similar conditions the efficiency of several currently recommended formulae for poisoning prairie dogs. Both fall poisoning and spring poisoning were included in these experiments, and ten of the formulae in most current use or most recommended were tested. In this way it is hoped that our ranchmen will be enabled to adopt the best methods of prairie dog eradication by poisons

from the start, rather than to use formulae of inferior efficiency.

Arrangements were made by the writer with Mr. J. J. Westcott of the firm of Westcott and Gibbons of Comstock, Custer County, to conduct the planned series of experiments on the ranch of Mr. Gibbons near Comstock, where there was a small, somewhat isolated colony suitable for the experiments and a large "town" containing thousands of dogs in the main range pasture. Mr. J. T. Zimmer was entrusted with the task of carrying out the experiments, and spent the period from October 22, 1912, to December 12, 1912, at this ranch, making the experiments in fall poisoning, while the spring poisoning was done by him between February 12, 1913, and April 15, 1913, each period thus covering about two months of work.

COMPETITIVE EXPERIMENTS IN FALL POISONING.

As a preliminary experiment, unpoisoned grain was placed near a number of dog burrows October 25, and later in the day this was found to be all gone wherever dogs had been seen to enter the holes. The grain remained untouched near holes where no dog had been seen to enter. This indicated that the animals would probably take poisoned bait readily when it was placed near occupied burrows.

The plan of operation was to test each of the ten formulae by placing some of the poisoned grain at each of 100 apparently occupied burrows, and subsequently noting and comparing the results. The original criterion for determining occupied burrows was to watch for the dogs to appear and then to mark such burrows with a stake. On October 26 and 27 about fifty such occupied burrows were noted and marked. This method, however, was found to consume too much time if rigidly adhered to, for every time a stake was so driven to mark an occupied burrow all of the animals for some distance around were frightened into their burrows, and would not venture forth again until some time had elapsed. Furthermore, some of the dogs are so wary that they will rarely appear above ground at all when a person is in sight, and this would inevitably lead to many unmarked and therefore unpoisoned, tho certainly occupied, burrows among the marked ones, while the marked burrows made according to this criterion proved to be scattered too much to fairly represent a unit group. Accordingly, the original criterion was modified so that all burrows which on examination showed signs of recent occupancy were staked along with those at which the animals were actually seen, so as to form 100 apparently occupied burrows in a compact group.

The plan further contemplated the placing of the poison on a favorable day, and a week was to be given the animals to take it. During this week the number of dogs found dead in the poisoned area would be noted, altho as most of them would die in their burrows these data could have no final value in determining the actual efficiency of the poison. At the end of the week all of the 100 apparently occupied and treated holes would be plugged with soil and then watched to ascertain how many were dug out from within, care being taken not to count burrows which had been dug open from without by other dogs, as at this time the animals were moving about thru the "town" considerably, tho not enough to seriously vitiate the value of the experiments. In cases of doubt a burrow was to be replugged. The compact nature of the 100 marked burrows would tend to minimize the disturbing factor of extraneous opening of the burrows.

Formula 1.—This formula was recommended by A. T. Peters of this Station in 1900 (1). It is prepared as follows:

Dissolve completely 3 ounces of strychnia sulfate and one-half pound of potassium cyanide in 1 quart of boiling water. Add 2 quarts of molasses and 1 teaspoonful of oil of anise, and stir until thoroly mixed. Pour this mixture over a bushel of wheat in a tight receptacle, stirring well, and at the same time sprinkling in 4 pounds of finely ground corn meal. The molasses is to render the liquid adhesive so that it will cling to the grains of wheat, while the corn meal absorbs the superfluous liquid and thus enables the grains of wheat to carry more of the poison. For the best results use this poisoned grain while fresh, placing it about every burrow, or, if there are grazing animals in the "town," in the entrance of the burrow.

The 100 apparently occupied burrows were staked November 2. November 6 promised to be a fine day so the formula was made up and the poisoned grain placed. On November 7 live dogs were seen, but they were perhaps not so abundant as before. November 8 the poison was seen to be disappearing gradually, and, altho only a few live dogs were seen, no dead ones were found out of the burrows. November 9 one dead dog was found and only a few live ones seen. November 13, one week after placing the poison, all of the 100 burrows were plugged, but live dogs were seen in three of these burrows at the time of plugging. No more dead dogs were found. November 16 two more of the plugged burrows were opened from within and on November 18 five additional burrows were open. On December 6 ten of the 100 treated burrows were shown to be occupied, making the total effectiveness of the treatment presumably 90 per cent.

Formula 2.—In 1902 D. E. Lantz modified the Peters formula as follows (4):

Dissolve $1\frac{1}{2}$ ounces of strychnia sulfate in 1 quart of hot water. Add a quart of syrup—sorghum, molasses, or thick sugar and water—and a teaspoonful of oil of anise. Thoroly heat and mix the liquid. While hot pour it over a bushel of clean wheat and mix completely. Then stir in 2 or more pounds of fine corn meal, the quantity needed depending upon the amount of extra moisture present. There should be enough to wet every grain of the wheat and no more. Let the poisoned grain stand over night and on the morning of a bright day distribute to each occupied burrow, putting it near the mouth of the burrow.

One hundred apparently occupied burrows were staked November 5. The above formula was made up on the evening of November 6 and the poisoned grain placed the following morning. On November 13 one dead dog was found. November 14, one week after the poison had been placed, all the 100 burrows were plugged. On November 16 three of these holes were opened from within, and no more were subsequently opened from within. The check on December 6 showed the probable effectiveness of the treatment to be 97 per cent.

Formula 3.—At the same time Lantz (4) further modified the Peters formula, not only reducing the strychnine and syrup but substituting coffee berries and white of egg for oil of anise, as follows:

Dissolve $1\frac{1}{2}$ ounces of strychnia sulfate in 1 quart of hot water. Add a quart of syrup—molasses, sorghum, or thick sugar and water. Previously soak 2 ounces of green coffee berries in the whites of 3 eggs and let this stand for 12 hours. Add the liquid of this to the poisoned syrup, thoroly heat and mix. While hot pour it over a bushel of clean wheat and mix completely. Then stir in 2 or more pounds of corn meal, according to the amount of superfluous moisture present. Use as formula 2.

The 100 holes were marked November 18. The formula was made up on the evening of November 19, and the poisoned grain distributed November 21. On November 25 the poisoned grain had scarcely been disturbed and there were numerous live dogs. At the end of the week following the distribution of the poison (November 29) the burrows were plugged. November 30 two of the plugged holes had been opened from within. A doubtfully opened hole was replugged and was again opened, from within, December 4. The efficiency December 6 was apparently the same as that of formula 2 (97 per cent), three burrows showing occupancy.

Formula 4.—C. H. Merriam in an important article on the prairie dog published in 1902 (5) recommended the following formula, which also omits the oil of anise, but without a substitute:

Dissolve $1\frac{1}{2}$ ounces of strychnia sulfate in warm water. Soak 1 bushel of wheat in this for 24 to 36 hours, until all is absorbed. Stir in a quart of molasses and sprinkle with enough corn meal to prevent sticking.

November 18 the 100 burrows were marked and that evening the above formula was made up. The grain was placed on the morning of November 19. Six days later (November 25) the poison had hardly been touched and there were numerous live dogs, so the plugging was delayed until November 29, 10 days after placing the poison. One hole was opened from within November 30, and later three others, apparently opened from within, were found. These were replugged and not subsequently reopened. On December 6 the presumed efficiency of this treatment was 96 per cent.

Formula 5.—Along with the preceding formula Merriam (5) suggested the following one, which does not allow for soaking the wheat and which was presented in the following definite form by J. E. Payne (8) in 1903:

Dissolve two ounces of strychnia sulfate in warm water. Add one quart of molasses and thoroly mix this with one bushel of wheat. After all of the liquid is absorbed add enough corn meal to prevent the grains sticking together.

The 100 burrows were marked October 27, but on October 29 the weather turned cold and the dogs remained in their burrows so that the poisoned grain was not put out until November 4. On November 5 one dead dog was found, but the poison did not seem to have been taken at many of the burrows, and live dogs were seen in numerous burrows. November 6 was a clear fine day with the dogs active, and one sick dog was just able to crawl into its burrow before it could be reached. On November 7 live dogs, tho yet present, were not so numerous as previously, and one nearly dead dog was found. Only a few dogs were seen November 9. On November 11, one week after the poison had been placed, the 100 burrows were plugged. November 12 five were opened from within, and several others were partly or wholly opened, apparently from without, so were replugged. November 13 a replugged burrow was found reopened, and a very sick dog found. On November 14 three live dogs were seen digging at plugged burrows from the outside, but they ran to unstaked burrows when disturbed; also a dead animal was found near one of these unmarked burrows. November 15 another

replugged burrow was reopened, and on November 18 another dead dog was found at an unmarked burrow. The record on December 6 showed seven burrows occupied, giving an efficiency of 93 per cent for this treatment.

Formula 6.—In 1908 Merriam (14) revised his formula of six years previously to the following one, chiefly by omitting the molasses and corn meal and simmering the poisoned solution and grain together:

Dissolve $1\frac{1}{2}$ ounces of strychnia sulfate in $2\frac{1}{2}$ gallons of water by heating in a covered receptacle. After the poison is thoroly dissolved add 1 bushel of grain (wheat), and allow the mixture to simmer in a closed vessel, stirring occasionally, until the moisture is taken up by the grain; or, the mixture may be allowed to stand over night to absorb the free moisture.

For this formula 100 apparently occupied holes were marked with stakes November 2. On November 6 the above formula was prepared and the poisoned grain distributed. Live dogs were present November 7, tho perhaps not so numerous as before. November 8 the poison was noted to be gradually disappearing and only a few live dogs were seen. November 9 a few live dogs were seen. The first dead dog was found November 13 and live dogs were seen in one burrow. At the end of the customary week, November 13, all the burrows were plugged. November 14 one burrow was opened from within; November 16 two more burrows had been opened; November 18 three more burrows had been opened, making in all seven burrows occupied at the checking on December 6 which gave an apparent efficiency of 93 per cent.

Formula 7.—In 1909 Lantz (15) proposed the following formula, which is about the same as formula 5, only there is less strychnine, and sugar syrup is used instead of molasses:

Dissolve $1\frac{1}{2}$ ounces of strychnia sulfate in a quart of boiling water and add a quart or more of thick sugar syrup. Pour this mixture over a bushel of wheat in a clean metal vessel and stir until all of the wheat is wet. Stir in corn meal to take up any surplus moisture, if the poison is to be used immediately (or add more water and leave the wheat to absorb the strychnine over night if not to be used immediately).

The 100 burrows were staked October 28, but cold weather came and they were not treated until November 4. In the morning of November 5 one dead dog was found and later in the day one very sick dog was seen. Many burrows had the poison apparently untouched, however, and there were numerous living, if not healthy, dogs in the marked area. On November 6 two dogs died outside of their burrows. November 7 live dogs were

still present but not so numerous. November 8 the poisoned grain was disappearing, and, altho there were no dead dogs found, the living ones were few. November 9 only a few dogs were seen. At the end of the week (November 11) the burrows were all plugged. November 12 three were opened from within and were replugged. November 16 these three replugged holes were found reopened from within. The apparent efficiency of the treatment, as checked December 6, was 97 per cent.

Formula 8.—In 1901 the Kansas Agricultural Experiment Station purchased for use in that State from Mr. D. W. Staples, then of Quanah, Texas, a patented formula claimed to be effective at any season, and which seems to have given the best results in Kansas. The patent to this formula expired July 28, 1908. It is given by Scheffer in 1909 (16) as follows:

Mix 1 ounce of green coffee berries with the white of 1 egg and allow to stand at least 14 hours. Dissolve 1 ounce of powdered strychnia sulfate in one-half pint of boiling water. Dissolve 1 ounce of potassium cyanide in a quarter of a pint of hot water and allow it to cool. Add a little warm water to the mixture of coffee and eggs and mix it with the potassium cyanide. Then strain this mixture thru a coarse sieve into the mixing vessel and add one pint of syrup. Mix $1\frac{1}{2}$ ounces of alcohol with the hot solution of strychnine and add it to the other mixture. Stir all thoroly, and use 2 quarts to each bushel of wheat, pouring it over the grain and stirring until every grain is wet with the poison. Stir in 2 or 3 pounds of fine corn meal to take up the extra moisture. Allow to stand over night and place some at the outside of each burrow.

One hundred burrows were staked November 18. The above formula was made up in the evening of November 19 and the poisoned grain distributed November 21. On November 25 the poisoned grain had hardly been touched and there were numerous live dogs. The burrows were plugged after eight days (November 29). November 30 no holes were opened. Later a hole was opened, replugged, and reopened from within December 4. The presumed efficiency December 6 was 99 per cent.

Formula 9.—The following formula, perfected by the Bureau of Biological Survey in 1910 for use against ground squirrels (*Citellus* spp.)¹ is recommended also by R. E. Clark in 1912 (17) as very effective against the prairie dog:

Dissolve one-half teacupful of ordinary laundry or gloss starch in a little cold water and add a pint and a half of boiling water, making a rather thick solution. While hot, stir in 1 ounce

¹Merriam, Circular 76, Bureau of Biological Survey, p. 10.

of ground or powdered strychnia sulfate and mix until free from lumps. Add 1 teaspoonful of saccharine and beat thoroly. Pour the poisoned starch over 20 quarts of clean grain (barley or wheat) in a galvanized iron washtub and stir rapidly until the poison is evenly distributed. Then allow the grain to dry and it will keep indefinitely without deterioration.

One hundred burrows were marked November 13. The above formula was prepared in the evening of November 13 and the poisoned grain put out the following day. The burrows were plugged a week later, November 21. Several were opened. No dead dogs were found. Apparent efficiency on December 6, 94 per cent.

Formula 10.—Mr. S. A. Johnson in 1912 (19) recommended the following as having given the best results in Colorado (Colorado formula 6):

Dissolve 1 ounce of powdered strychnine alkaloid (for which we substituted strychnia sulfate), one-half teacup of starch and 1 teaspoonful of saccharine in 1 quart of boiling water. Pour it over 12 quarts of grain (barley, wheat, or oats) which is held in a tight vessel, as a galvanized iron tub (which should subsequently be scrubbed clean). Stir the mixture very thoroly until every grain receives a thoro coating, then spread the grain out to dry. It will keep indefinitely. Sprinkle on the mounds of the occupied burrows.

The burrows were selected and staked November 18, and in that evening the above formula was prepared, except that strychnia sulfate was substituted for the strychnine alkaloid, because of its greater solubility in water and less cost. Early the next morning the poisoned grain was distributed, and a week later (November 26) the burrows were all plugged. One burrow was seen to be occupied when plugged. November 27 an opened burrow seemed to have been opened from the outside but was replugged. November 29 no new burrows were opened. Three burrows opened from the outside were later replugged. On December 4 one dead dog was found. On December 6 no new plugged or replugged burrows were open, showing an apparent efficiency of 99 per cent.

Summarizing, the apparent efficiency of the 10 poisons, made according to the original formulae, was as follows:

FORMULA	PER CENT	FORMULA	PER CENT
1.....	90	6.....	93
2.....	97	7.....	97
3.....	97	8.....	99
4.....	96	9.....	94
5.....	93	10.....	99

But this is presuming that each of the 100 selected burrows was actually occupied, for as we have seen, burrows were selected which *seemed* to be occupied, as well as those which the dogs were actually seen to enter. In order to check this source of error, and reduce the above relative efficiency percentages to their approximate actual percentages, 100 burrows were selected in the same way as the other 10 sets of 100 burrows and marked December 9. On December 12 they were all plugged. At the same time 34 additional burrows at which dogs were *seen* to enter were plugged. On the next morning 4 of these 34 burrows were open and on December 16, 31 of them were open, while the next day (December 17) all were open. It is thus obvious that an occupied plugged burrow will be opened within a week. On December 16, 37 of the hundred burrows plugged December 12 were open. This proportion is without doubt small, as in formula 5 at least one-half of the burrows were *known* to be occupied since they were marked where the animals were seen to enter. But assuming that only 37 per cent of the selected burrows were occupied, we yet have a probable actual efficiency as follows, the relative efficiency remaining the same:

FORMULA	PER CENT	FORMULA	PER CENT
1.....	73	6.....	81
2.....	92	7.....	92
3.....	92	8.....	97
4.....	89	9.....	84
5.....	81	10.....	97

Obviously, formulae 8 and 10, which have given the best results in Kansas and Colorado, respectively, are the most efficient poisons in these experiments. Of the two, formula 10 is the more easily and quickly prepared, and the conclusion is reached that it is the most generally satisfactory formula to use.

The Colorado investigators have recently (20-23) proposed a new formula (Colorado formula 15) as a substitute for foregoing formula 10 (Colorado formula 6) which they state is more readily taken by the animals. It is prepared by dissolving 1 ounce of powdered strychnine alkaloid and 1 teaspoonful of saccharine in $1\frac{1}{2}$ or 2 pints of water, adding three-fourths of a pint of flour and one-half pint of fine salt, mixing the whole thoroly with a Dover eggbeater, putting the mixture over a fire in a granite stewpan and bringing it to the boiling point, or heating until the flour begins to thicken, stirring constantly. Pour the poisoned mixture over 12 quarts of wheat or barley and thoroly mix, then spread and dry the grain. We have not tried this formula, but

it can hardly be more economical or effective than formula 10 above described, and seems to be somewhat more troublesome to prepare.

COMPETITIVE EXPERIMENTS IN SPRING POISONING.

In the spring poisoning it was decided to test still further five of the formulae used the preceding fall, including the two which had given the best results: viz, formulae 2, 6, 8, 10, and a modification of 10 to be designated as 10a. In these experiments, with fewer burrows to mark by stakes, the original criterion for determining occupied burrows was to be rigidly adhered to in spite of the difficulties encountered, and only those burrows into which the dogs were actually seen to enter were to be marked and treated.

The earlier work in the spring was much interrupted by inclement weather. From the date of the return to Comstock, February 12, 1913, until February 17, the weather was so unfavorable for the purposes of the experiments that the work was confined to making observations and to selecting favorable sections of the valleys for the work to be done later. February 17, however, was a fine bright day with nearly every dog out, and 375 burrows were noted as occupied, and properly marked. A period of cold, snowy weather from February 18 to March 3 kept the animals in their burrows, and until the 8th only a few ventured out, these mostly on March 4 and 7. March 8 and 9 were very fine days and formulae 2 and 6 were then placed. March 10 was unfavorable and caused a day's delay, the 11th was cloudy and windy but warm, while from the 12th to 16th was a period of storms and blizzards. March 18 opened unfavorably but grew pleasant later in the day, about as on February 17, but this day was succeeded by cold, cloudy, and stormy weather from the 19th to the 26th, again interrupting the work, as only a very few dogs were observed during this period. On March 27 the stormy weather began to abate and the experiments were not again seriously interrupted, except on March 30, April 3 and 8 to 11, which were days too stormy for successful work.

Formula 2.—On February 17, which was a fine, bright day with almost every dog out and active, 100 burrows, known to be occupied by the actual observation of the animals entering them, were marked. February 18 to March 7 was a period of almost continuously cold, stormy weather with much snow, so that prairie dogs appeared above ground only at intervals (e. g. March 4) and then only a short time and in very small numbers. As a result the treating of these burrows was postponed until March 9, when the finest weather of the spring up to that time

was experienced. The poisoned grain was prepared in the evening of March 8 and distributed the following day to the 100 burrows selected February 17. On March 10 two dead dogs were found and about 25 live ones were seen, but the poisoned grain had disappeared from only a few of the burrows, being apparently untouched at most of them. March 12-16 was stormy, with the dogs keeping in their burrows, but on March 18 the day turned pleasant and the dogs came out, 30 being noted at the marked burrows.

On the morning of March 31 a second application was made using oats as the grain instead of wheat. On April 12, a clear, fine day, suitable for making a final check count, as almost every dog was out, it was found that there were still 25 live dogs in the 100 burrows.

Formula 6.—On February 17, at the same time that the 100 occupied burrows were selected for formula 2, 75 occupied burrows were selected in the same way for another test of formula 6. March 8 was the first bright day suitable for distributing poisoned grain, so early on that day this formula was prepared and the grain was put out at the 75 burrows, the dogs beginning to appear just as the distribution was finished. On March 10 3 dead dogs were found and 30 live ones noted; much of the poison had not been taken, altho in a few cases it was all gone. On March 18, following 5 or 6 days of stormy weather, the dogs reappeared above ground and 35 were noted at the marked burrows.

On the early morning of March 29 a second application was made using oats as the grain instead of wheat. On April 12, a bright day with the dogs out in force, a careful check showed that there were still 26 live dogs in the 75 burrows.

Formula 8.—Also on February 17, 100 burrows known to be occupied were selected and marked for a further test of this formula. On the evening of March 9 the formula was made up with the expectation of placing it the next day, but unfavorable weather postponed its placing until March 11, when the dogs came out abundantly in the afternoon, altho the day was cloudy and windy. The following day and the next five days were stormy, but on the 18th the dogs came out, and a check showed 36 live dogs in the marked burrows.

On the morning of April 1 a second application was made using oats as the grain instead of wheat. The final check count on April 12 showed 26 live dogs in the marked burrows.

Formula 10.—At 100 burrows marked as occupied on February 17, grain poisoned according to the Colorado formula 6 with the same modification as was used the preceding fall, i. e., the sub-

stitution of strychnia sulfate for strychnine alkaloid, was placed on the morning of March 28. On April 1 in the middle of the day a check of those burrows showed 23 live dogs.

On the morning of April 2 a second application was made, using oats as the grain instead of wheat. When a final check was made on April 12, 23 live dogs were again found in the 100 burrows.

Formula 10a.—On March 18, 100 burrows into which dogs were seen to go were marked as occupied. On March 28 these were treated with grain poisoned according to the original Colorado formula 6, using strychnine alkaloid instead of strychnia sulfate. On April 1 in the middle of the day a check of these burrows showed 24 live dogs.

On the early morning of April 4, which was a clear, warm day, a second application was made using oats as the grain instead of wheat. The final checking on April 12 showed 24 live dogs, the same as on April 1.

Summarizing, the efficiency of the five poisons used in the spring poisoning experiments was as follows:

TABLE 1.—*Efficiency of five poisons used in the spring poisoning experiments.*

Formula	Original number of dogs in burrows	Number of dogs after 1st application (with wheat)	Number of dogs after 2d application (with oats)	Efficiency of 1st application	Efficiency of 2d application
				<i>Per cent</i>	<i>Per cent</i>
2	100	30	25	70	17 —
6	75	35	26	53 +	26 —
8	100	36	26	64	28 —
10	100	23	23	77	0
10a	100	24	24	76	0

It will thus be seen that the first application (with wheat) was quite satisfactorily effective, the formulae ranking in effectiveness as 10, 10a, 2, 8, and 6, the same as in the fall experiments except that 10a was not used in the fall and that 8 and 2 exchanged places in rank. There is apparently little difference in effectiveness whether strychnia sulfate (10) or strychnine alkaloid (10a) is used in formula 10, tho in the above experiment the former seems to give slightly better results. The keeping qualities and ease in handling of grain poisoned by this formula were excellent.

More dogs were destroyed with the first application of this poison than with both applications of any of the others. The second application was largely a failure, partly due to the lateness of the season when it was put out (March 29 to April 4), as a rather large amount of green food was available and being utilized by the dogs, and partly because of the fact that oats is a poor grain to use in poisoning prairie dogs. The lowered general percentages of efficiency would indicate the superiority of fall poisoning over spring poisoning, as the weather is more regular and dependable, and the dogs are more active and more eager to eat the poisoned grain.

One reason for the unsatisfactory showing of oats as compared to wheat is that the animals are likely to shell off the outer coat of the grain, thus discarding most or all of the poison, so that the grain can be eaten without poisoning them. The shelled hulls of the oats could be found commonly about the burrows. Moreover the lightness of the oats grains caused them to blow about more readily than wheat, both when being put out and later. Altogether wheat was seen to be a much more suitable grain for poisoning with strychnine than the available oats, and probably a more economical one to use in spite of the difference in cost. However, the Biological Survey used oats poisoned according to formula 9 in the National Forests of Colorado and New Mexico with success. Naked barley may probably be used with satisfactory results wherever available.

DEMONSTRATION POISONING EXPERIMENTS.

When the comparative superiority of formula 10 was ascertained by the checking of the results of the competitive fall tests of the 10 formulae just outlined, on December 6, it was decided to test this formula further, on a larger scale and under the most unfavorable conditions. Accordingly, on December 7, 18 quarts of poisoned wheat was prepared according to formula 10 (requiring $1\frac{1}{2}$ hours to prepare), was well dried the next day, and on December 10 part of it was placed in a heavily infested alfalfa field where fresh food (alfalfa roots) was available. It required two men an hour to place grain enough to treat this field. On December 11 the poisoned grain was apparently yet untouched, and all subsequent checks, beginning December 12 and continuing to December 17, failed to show any dead dogs in this alfalfa field, or any indication that their number had been seriously reduced.

On December 13 and 14 the remainder of the eighteen quarts was distributed about burrows on the range pasture where fresh

food was scarce. It required two men four hours to place this grain. The area covered was about eighty acres and contained about 2,500 burrows. By actual count the concentrated part of this "town" contained from 130 to 150 burrows in an area 100 yards square containing 10,000 square yards. On December 14 2 dead dogs were found; on December 15, 15 dead dogs were found and the animals were obviously much less abundant than previously in the treated area; December 17, 3 more dead dogs were found and only 7 live dogs were noted in the field, while only 4 burrows showed signs of occupancy; December 18, 3 more dead dogs were found; and on December 20 a very sick dog was seen. Altogether the mortality following this latter application was exceedingly heavy, in striking contrast to the failure of the contemporaneous application in the alfalfa field. Clearly, this demonstrated the futility of trying to destroy prairie dogs with poisoned grain when the animals can get an adequate supply of fresh food. But on range pastures during the late fall, winter, and early spring poisoned grain is a very effective treatment.

As a further test in the spring the big range pasture was completely gone over and all of the burrows were treated with formula 10 March 28 and April 14. In doing this work 83 quarts of wheat and 24 quarts of oats were used, and it required 47½ hours of time to distribute these 107 quarts of poisoned grain. The exact time and material used was as follows:

TABLE 2.—*Time required and material used in an extensive application of formula 10.*

Date	Time	No. of men	Total hrs.	Grain used	Quantity of grain	
					Wheat	Oats
	<i>P. M.</i>				<i>Quarts</i>	<i>Quarts</i>
March 28	3-5	5	10.0	Oats	12	20
March 29	3-5	4	8.0	{ Oats and Wheat }	12	4
March 31	3-4:30	3	4.5	Wheat	15	..
April 1	3-5	5	12.0	Wheat	24	..
April 5	3-4	5	5.0	Wheat	12	..
April 14	3-5	4	8.0	Wheat	20	..

From April 8 to 11, after most of the range pasture had been treated, a close survey of the area showed that the number of dogs had materially decreased, altho the small number seen might in part be accounted for by the fact that the period was a stormy one, which would tend to keep the animals in their burrows.

The application on April 14 included the infested alfalfa field unsuccessfully poisoned the preceding fall. On April 15, when the final check was made, it was estimated that 75 to 80 per cent of the prairie dogs on the range had succumbed to this extensive application of formula 10.

Other demonstration tests were made with other formulae both in the fall and spring. An application of formula 3 at unstaked burrows on November 21 showed dead animals on November 26 and an application of formula 4 at unstaked burrows on November 21 showed six dead dogs and a very sick one on November 22, and two more dead dogs November 21, but neither of these showed results as satisfactory as those following the use of formula 10.

EFFECT OF POISONING ON OTHER ANIMALS.

One point of especial observation was the result of the application of poisoned grain about the prairie dog burrows on the bird and mammal life of the region. Our observations, as well as those of others (17, 23), indicate that very few birds are killed by the exposure of this poisoned grain. In the fall experiments three Desert Horned Larks (*Otocoris alpestris leucolaema*) were found dead because of having eaten poisoned grain, one on November 16, 22, and 25, respectively. A dead white-footed mouse (*Peromyscus maniculatus osgoodi*) was found December 14 and another the following day. Coyotes carried away most of the dogs which died above ground; of the 15 dead dogs seen in the pasture December 15 following the application of formula 10 all had been carried away by December 17.

FUMIGATION OF BURROWS.

Several gases have been tried out as a means of destroying prairie dogs by asphyxiating them in their burrows, but carbon bisulfid has apparently given the most uniformly successful results. The use of Pintsch oil was first recommended as the result of experiments made by the Nebraska Station (10) and the success of this method, if the oil is of good quality and used under wet soil conditions, has been corroborated by Colorado experimenters (22). If purchased in barrel lots (50 gallons) this oil is considerably less expensive than carbon bisulfid, even tho twice as much of it as of carbon bisulfid should be used; but when purchased in ordinary lots (at 35 cents a gallon) the saving is not great. It seems to be true, however, that the Pintsch oil does not run even, and that while one lot may be used with success another lot may prove a failure, so that carbon

bisulfid is probably more economical because of its dependability and in spite of its somewhat greater cost. Pintsch oil is used just as described below for carbon bisulfid. The use of sulfur fumes is said to be effective and the cost of sulfur is low, but it requires a machine to force these fumes into the burrow, and, considering the cost of such a machine (\$30), the tendency for it to wear out quickly, and the slowness and labor of its use, probably nothing is to be gained with sulfur fumes over the use of carbon bisulfid (6).

Carbon bisulfid (CS_2) is a colorless liquid which evaporates very quickly, forming a vapor heavier than air and which therefore naturally sinks to the bottom of a prairie dog burrow. This vapor has a very disagreeable odor, but unless breathed in considerable quantities has no injurious effects. It can be handled out-of-doors by carrying it in a spouted kerosene or oil can, and no special precautions need be taken except that no fire may be brought near the liquid or vapor as it is highly inflammable and somewhat explosive. For this reason it must not be handled by a man who is smoking, nor opened near a fire of any sort. It is usually used by pouring about an ounce on some porous material, such as dried horse droppings, dropping this into the burrow and then plugging the opening of the burrow with soil. It should be kept in perfectly tight cans which should always be corked when not in actual use.

The chief objection to carbon bisulfid as a destroyer of prairie dogs has not been a lack of effectiveness on its part, but that the expense of the material is high, two or three times that of a poisoned grain application, and the labor of applying it considerable. This high cost of an application (20 to 60 cents an acre) practically bars its extended use as a primary method, that is, as a destroying agent in the first "going over" of a colony. But after the prairie dogs have been greatly reduced in number by the use of poisoned grain and only the wary old dogs which steadfastly refuse to take poisoned food remain, this small but important residue of the colony can be destroyed with celerity by the carbon bisulfid treatment, and on this reduced scale its use is neither prohibitively expensive nor excessively laborious. Its use should be confined to burrows known or strongly suspected to be occupied by one or more of the animals, and it usually gives the best results if used after a rain when the interspaces in the soil are more or less clogged with water, so as to retard the diffusion of the vapor thru the soil. Also, in alfalfa and grain fields, or in colonies supplied with an abundance of green food, it seems to be the best way of getting rid of the animals.

FUMIGATION EXPERIMENTS.

In the fumigation experiments carbon bisulfid was the only fumigant used, altho a series of experiments using different dilutions of the carbon bisulfid with gasoline as recommended by Lantz (4, 6) was also carried out for purposes of comparison. The object was to determine the minimum effective dosage and the best means of applying the chemical.

The first fumigation experiments were made by J. T. Zimmer at Comstock in March and April of 1913, but the data obtained



Fig. 3.—An occupied prairie dog burrow just after treating with carbon bisulfid (above); a burrow after it was treated, plugged, and marked (below). Haigler, Nebraska.

by him were incomplete and not conclusive. Mr. L. M. Gates completed these experiments in the spring of 1914 (May 23-31) on the ranches of Messrs. Casey and Green, respectively one and four miles east of Haigler, Nebraska.

The plan of the experiments with carbon bisulfid was essentially the same as those with poisons. A burrow into which a prairie dog was seen to enter, and which was therefore known to be occupied, was selected and treated. The treated burrow was then plugged or sodded tightly and marked with a stake (fig. 3). For several days subsequent to the treatment the burrow was examined and its condition noted. If any one of the burrows was opened from the inside it was, of course, assumed that the treatment of that burrow was unsuccessful, but if it was not opened from the inside within a week it was assumed that the occupant had been killed by the fumigation. To make more certain that burrows opened from the inside were really occupied, such burrows were promptly reclosed. One hundred burrows were thus marked and treated, the amount of carbon bisulfid and the method of application being varied in 10 different ways so that sets of 10 burrows were treated exactly alike. The results follow:

1. On May 25, 10 burrows (1-10) on the Casey ranch were treated with one-half of a fluid ounce (about 1 tablespoonful) of carbon bisulfid, applied by soaking dry horse manure balls (5 burrows) or dry cow chips (5 burrows) with the chemical and dropping them into the burrows. The next day burrows 3, 4, and 8 were open from within, and these were reclosed. No more were open May 27 or 28. On May 29 burrow 5 was open and this was also reclosed, while on May 30 burrow 9 had been opened, and when closed was reopened May 31. Thus, five of the ten burrows showed that they contained live occupants within a week after the treatment, or that the treatment did not result in a mortality of over 50 per cent.

2. On the same day ten adjacent burrows (11-20) were treated with 1 ounce of carbon bisulfid applied on dry horse manure balls. These were examined every day from May 26 to 31 and only one was opened, that being burrow 15 on May 27, tho burrows 11 and 12 were dug into from the outside but not opened. Apparent mortality, 90 per cent.

3. On May 23 and 24, 10 burrows (21-30) in a wheat field on the Green ranch were treated with $1\frac{1}{2}$ ounces of carbon bisulfid on dry horse manure balls. On May 24 one of the burrows treated the preceding day (21) was open, and on May 27 another (30) was open. Both were reclosed and not subsequently reopened. May 31 burrows 23 and 25 had been opened apparently

from the outside, tho burrow 25 was well opened. Apparent mortality, 80 per cent.

4. On the same days, 10 additional burrows (31-40) in the same "town" were similarly treated except that 2 ounces of carbon bisulfid were used to each burrow. Examination each day (except May 29) showed that no burrows were opened from within. Apparent mortality, 100 per cent.

5. On May 23, 10 burrows (41-50) mostly in a wheat field on the Green ranch were treated with $2\frac{1}{2}$ ounces of carbon bisulfid applied on dry horse manure balls. On May 27 burrow 48 was open and when immediately replugged was reopened May 31. Apparent mortality, 90 per cent.

6. On May 23, 10 burrows (51-60) on the Green ranch were each treated with 1 ounce of carbon bisulfid applied on dry corn cobs. Altho examined every day (except May 29) for the next eight days none of these burrows were opened except that on May 26 burrow 52 was opened from the outside. Apparent mortality, 100 per cent.

7. On the same day 10 burrows (61-70) on the Green ranch were each treated with two ounces of carbon bisulfid applied on dry corn cobs. These likewise were examined every day (except May 29) until May 31 and none were found opened. Apparent mortality, 100 per cent.

8. On May 25, 10 burrows (71-80) on the Casey ranch were each treated with 1 ounce of carbon bisulfid applied on cotton rags. On May 26 burrow 75 was open and on May 28 burrow 74 was open. On the latter date burrows 71 and 77 were also more or less open; 71 was not fully opened, but the hole was barely large enough for an adult dog to force its way thru and escape, while 77 had only a very small opening and no work had been done about the burrow. On May 30 burrow 74 was reopened with a similar small hole. It is considered improbable that any of these last three openings were made by the adult dog seen to enter the burrow before the treatment. Apparent mortality, 80 per cent.

9. On the same day 10 burrows (81-90) on the Casey ranch were each treated with 2 ounces of carbon bisulfid applied on cotton rags. On May 29 burrows 83 and 90 were open, as was also burrow 86 but the opening in the latter was very small and not made by the prairie dog. Apparent mortality, 80 per cent.

10. On the same day each of 10 burrows (91-100) on the Casey ranch had one ounce of carbon bisulfid carefully poured down into the hole. The ground was quite moist at the time from rains of the preceding week so that maximum efficiency from this method could be expected. Altho examined every day

for the next six days none of these burrows were opened. Apparent mortality, 100 per cent.

From the above experiments one may conclude that one-half of a fluid ounce of carbon bisulfid is insufficient for the dosage of the average prairie dog burrow, because not over one-half of the animals succumb to such a treatment, but that 1 ounce is a sufficient dosage to kill 80 to 100 per cent of the animals. An increase in dosage to $1\frac{1}{2}$, 2, or $2\frac{1}{2}$ ounces does not consistently add to the effectiveness of the fumigation. When the soil is moist from recent rains good results will follow the simple careful pouring of the ounce of carbon bisulfid into the burrow, but probably the most consistently satisfactory results will follow the use of the chemical on dry corn cobs. Good results will also follow the use of the carbon bisulfid on dry horse manure balls, but cotton rags or waste as a medium have in these experiments not been so effective.

If carbon bisulfid is used at the rate of 1 fluid ounce (2 table-spoonfuls) to the burrow, and if it is purchased for small colonies by the pound in lots of 5 pounds or more, when it can usually be obtained for about 15 cents per avoirdupois pound even in villages, one pound making between 14 and 15 fluid ounces, the cost of the material is about 1 cent a burrow. If purchased in 5 gallon cans (at about \$1 a gallon) as it would be for large colonies, the cost per burrow is reduced to about four-fifths of a cent. The average time of application and plugging for one man in the above experiments was about $4\frac{1}{2}$ minutes to the burrow, varying from 3 minutes to the burrow in experiments 2 and 10 to 6 minutes in experiment 6, but where the work is being done with only approximate accuracy a man would probably be able to treat and plug at least 200 burrows in a day, at a cost of about \$1.50 to \$2 for material, making the total cost for material and labor (at \$2 a day) about 2 cents a burrow.

In diluting carbon bisulfid with gasoline, 2 ounces of a mixture of 1 part of the carbon bisulfid with 4, 3, 2, and 1 parts of gasoline, respectively, were tried out on the Casey ranch, using dry horse manure balls as the medium; also one ounce of the equal mixture of the two was used. The results follow:

11. Ten burrows (101-110) treated and plugged May 25 with 2 ounces of carbon bisulfid diluted with gasoline, 1 part to 4 of gasoline, on dry horse manure balls, showed 1 burrow (105) reopened May 26, again May 29 and 30, and a fourth time May 31. Burrow 108 was opened May 28. Apparent mortality, 80 per cent.

12. Ten burrows (111-120) similarly treated May 25 with a dilution of 1 part to 3 of gasoline, showed two burrows (111 and

118) open May 29, one of them (111) from the outside, but this burrow when replugged was reopened from the inside May 31. Burrow 115 had caved in May 26, apparently without a dog having emerged or entered, but was also fully open May 29. Burrow 116 was dug into from the outside but not opened May 29. Apparent mortality, 80 per cent.

13. Ten burrows (121-130) similarly treated May 26 with a dilution of 1 part to 2 of gasoline, showed burrow 127 dug into from the outside but not opened May 29, open May 30, and reopened May 31, when burrow 130 was also open. Apparent mortality, 80 per cent.

14. Ten burrows (131-140) similarly treated May 26 with 2 ounces of carbon bisulfid and gasoline in equal parts showed burrows 133, 139, and 140 open on May 29, while 140 was reopened May 31. Burrows 131 and 135 were partly open May 27 and 28, respectively, obviously from the outside. Apparent mortality, 70 per cent.

15. Ten burrows (141-150) similarly treated May 26 and 27 with carbon bisulfid and gasoline in equal parts, but using only 1 ounce to the burrow, showed 141 reopened on May 27, 28, and 29, and burrow 145 reopened on May 29 and 31. Apparent mortality, 80 per cent.

As a check on the preceding 15 experiments, on May 27 10 occupied burrows (1-10) were plugged without treatment. May 28 burrows 1, 4, 6, 7, 8, 9, and 10 were all open, May 29 burrows 1, 6, 7, and 8 were reopened and 5 had a small opening, May 30 burrows 1, 6, 7, and 8 were again reopened, May 31 burrows 4, 5, 6, 7, 8, and 10 were open and burrow 2 was dug into from the outside. Thus within four days after plugging all but two of the burrows (2 and 3) had been opened, three of them (6, 7, and 8) four times, one (1) three times, two (4 and 10) twice, and two (5 and 9) once. Probably the others would have been opened within a week after the plugging.

In the fumigation experiments conducted by Mr. Zimmer at Comstock in March and April, 1913, the results with the more diluted carbon bisulfid were not so successful as in the Haigler experiments, possibly due to differences in soil conditions. The 1 to 4 dilution was used on 12 burrows March 4, on 15 March 7, on 10 March 8, and on a large number of additional burrows March 17. Subsequently a majority of these burrows were promptly opened from within. Some were refumigated with the same mixture with little success. On April 2, 4, and 5 many burrows were fumigated with the 3-to-1 mixture, with results only slightly more satisfactory.

We should judge that with diluted carbon bisulfid, as with the pure article, 1 ounce to the burrow is sufficient. However, one ounce of the pure carbon bisulfid seems to be more effective than an ounce of the carbon bisulfid mixed with an ounce of gasoline.

LESS SUCCESSFUL METHODS.

Our efforts have convinced us that trapping prairie dogs cannot be made a successful way of fighting them. We have succeeded in catching a few with concealed steel traps, but the process is slow and the small catch is wholly out of proportion to the large number of traps set. Traps are usually avoided unless carefully concealed. No. 0 steel traps carefully set with the trap, chain, and stake covered with loose soil will occasionally catch a prairie dog. We did not try other kinds of traps, but experimenters who have done so report them to be a failure. Shooting these animals is not a success both because of the difficulty of approaching them close enough and the fact that at the first shot the dogs scurry for their burrows, and will not venture forth again for some time, making the process exceedingly slow. Drowning out the animals, while possible if sufficient water supply is available, is also too slow to have any practical use, except of course on irrigated lands where they are held in check by the flooding. Nor has the use of disease cultures proved a practical way of exterminating these animals.

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VOLUME XXVIII, ARTICLE III.

ROTATIONS AND TILLAGE METHODS IN
WESTERN NEBRASKA.

REPORT OF EXPERIMENTAL SUBSTATION, NORTH PLATTE, NEBRASKA.

BY W. P. SNYDER AND W. M. OSBORN.

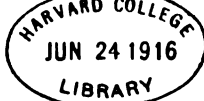
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¹Resigned.

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SUMMARY.

The following statements are based on the average results of eight years as given in this bulletin. It should be remembered that this work is on the high table-land and also that winter wheat is not considered in this report.

The weather conditions of the season during which the crop is grown are the greatest factor controlling yields.

The seasonal precipitation has a much greater influence on crop production than methods of seed-bed preparation, crop sequence, or manure.

During favorable seasons profitable crops have been produced by all methods, and during unfavorable seasons profitable crops have not been produced by any method.

The system of alternate cropping and summer tillage has failed to overcome severe drouth conditions and has been less profitable in the production of corn and spring grain than ordinary methods of production. However, this system, during some unfavorable years, has given a large increase in yields over common practices and thus has served as a partial insurance against entire crop failure.

From the standpoint of either yields or profits, it matters but little whether the land is fall plowed or spring plowed for spring grain or corn.

Tho spring grain planted on cornstalk land has not yielded more than when planted on spring-grain stubble, it has given more profit when grown on the corn land on account of there being less labor required in preparation for seeding on corn land.

Earnyard manure has not increased the yields sufficiently to pay for the application of the manure, probably because water rather than plant food is the factor controlling production under these conditions. However, we believe the use of manure is advisable as a security against a deficiency in fertility and humus.

Green-manure crops are too expensive for practical use under present conditions.

If a value of \$4 per ton is given to sorghum hay, this crop becomes one of the most profitable crops here considered. During favorable seasons and also under drouth conditions it has given a larger tonnage than any other crop.

As a single crop, corn ranks above any of the spring small-grain crops in profit returned where the stover and grain are both used.

Corn following corn has yielded 5 bushels more per acre than corn following small grain.

Spring wheat ranks next to corn in profit returned in these rotations. It gives the greatest profit where it follows corn.

Oats have proved the least profitable of the crops grown, and have usually been grown at a loss.

Neither alfalfa nor brome grass has been grown successfully in these rotations. The failure of these crops should be expected when grown on high table-land of this character, unless seeded in rows and cultivated.

Among the many rotations there was none in which the crops were grown according to common farm tillage practice conducted thoroly that did not give an average annual net profit of more than \$1 per acre.

The less expensive methods of tillage have given the most profit per acre.

The results of this work to date commend the common tillage practices of the farmers thruout this region in so far as these practices are conducted in a thoro and intelligent manner.

ROTATIONS AND TILLAGE METHODS IN WESTERN NEBRASKA.

BY W. P. SNYDER AND W. M. OSBORN.¹

INTRODUCTION.

The data reported in this bulletin are the results of experiments in rotations and tillage methods conducted on a series of one-tenth acre plats on the table-land during the past eight years. This bulletin is a means of reporting progress, or results thus far secured, rather than a report of conclusions drawn from a finished line of investigation. The results given should be considered as a means of comparing one method of tillage or one rotation or one crop with another, rather than as a basis for determining the average crop production in this region. While it is probable that the yields given in these tables are not far below or far above those secured on similar soil in this vicinity during these years, yet areas of one-tenth acre may be more severely injured by a hot wind or an invasion of grasshoppers than a large field. However, ten-acre fields of grain grown on this farm during these years gave about the same results as the small plats.

It should be remembered that this bulletin does not necessarily deal with the best and the poorest method of producing crops. Many methods are dealt with, and we trust that some of the poorer methods as well as some of the better methods

¹Assistant in Soils and Crops, Experimental Substation, North Platte, and Assistant Agriculturist, Office of Dry Land Agriculture, Bureau of Plant Industry, United States Department of Agriculture. Mr. Osborn resigned March 1, 1915, and was succeeded by Mr. L. L. Zook.

The data presented in this bulletin relating to climatic conditions and soil moisture have been obtained by the North Platte Substation in cooperation with the Biophysical Laboratory and Office of Dry Land Agriculture, Bureau of Plant Industry, United States Department of Agriculture.

The data from which this report is compiled were gathered in the years 1906 to 1912 inclusive by Mr. W. W. Burr, then Associate in Soils and Crops, North Platte Experimental Substation, and Assistant Agriculturist in Dry Land Agriculture, United States Department of Agriculture, who was transferred in March, 1913, to become Assistant in the Office of Dry Land Agriculture, United States Department of Agriculture. The data for 1913 and 1914 were gathered by Mr. W. M. Osborn, as above indicated.

have been tried. Some practices, such as spring plowing for corn or even fall plowing for corn, are not very practical under soil and climatic conditions which prevail in this part of the state but are being tried here in order to keep this work comparable with similar experiments being conducted in other States having quite similar conditions. It should also be noted that winter wheat, one of our most profitable crops, is not considered in this bulletin.

Yield per acre usually is taken as the measure of profitable production. A low yield means a small profit or a loss and a high yield means a large profit. But this is not necessarily true. Europe produces high yields per acre but small profits per man. The measure of good farming in America is profit per man rather than yield per acre. As the yield per acre is increased beyond a certain normal the cost per bushel, on the average, will be increased, tho in individual cases or during short periods of time the reverse may be true.

In considering the results of these eight years' tests, it has seemed that some attention should be given to the cost of production as represented in the profit per acre as well as the yield per acre. Not many farmers will agree on the prices that should be charged for each operation, but the prices used here are fair, at least, for comparing the results of the various methods and rotations. The final results show that some methods and rotations have given a profit, while others usually have given a loss. These facts should indicate that, so far as practical, certain methods of tillage, certain rotations, and certain crops should be used as little as possible.

That large profits are not apparent should not cause surprise. The farmer has received interest on his investment and wages for himself and teams. The returns here given are net profit. A farm survey of representative districts in Indiana, Illinois, and Iowa, made by the United States Department of Agriculture and reported in Bulletin 41 of the United States Department of Agriculture, states that the average labor income of the farmers who own and operate their farms in these districts was, in 1911, \$480 after the interest on the investment had been deducted from the profits and the farmer had been allowed the part of the living of the family usually secured on the farm. This figure is not quoted to indicate that the farmer does not make fair wages, but rather to indicate that when accurate methods of accounting are applied to farm operations the resulting figures may indicate that there is not as much net profit in any given operation as had been presumed.

While the results in crop production herein reported repre-

sent losses during severe years, like figures for almost any business enterprise would show similar results during periods of depression. Also, if we could include with this report the results the farmer secured by keeping live stock and feeding the roughage grown during these years, the final item of profit would look much more favorable. This report deals only with certain phases of the farmer's operations, and these phases are those most noticeably affected by unfavorable seasons. That the farmer did not get fair wages for growing a certain crop, by a certain method, during a certain year, is not sufficient basis for asserting that the farmer did or did not make money during that year. It is probable that the farmer who judiciously combined live stock with farming secured a profit during the most unfavorable season.

In order that a general and more comprehensive idea of the plan of the work may be had, Chart I has been inserted. The plats are 2 rods wide by 8 rods long, the area of each plat being one-tenth acre. The plats are arranged in groups or rotations ranging from two to six years in length. The rotations are also arranged so that each differs from the others in at least one particular. There are only two six-year rotations. In each of these a hay crop is used in order to conserve soil fertility and also to furnish a good quality of feed or pasture for live stock. The larger part of the work has been done with three- and four-year rotations. All of the standard crops grown in western Nebraska except winter wheat are used in these rotations and systems of cropping. Some of the rotations, systems of cropping, or methods of tillage are designed principally to conserve moisture or organic matter in the soil. The study of the work as here presented is made in such a way that the effect of cropping and tillage for only the one year preceding the crop is shown.

ROTATIONS AND TILLAGE METHODS

NORTH PLATTE, NEBRASKA

A OATS	B CORN F.P. 43	C RYE	A CORN S.P.	B WHEAT D	C BROME 41	D BROME	E BROME	F OATS F.P.	A WHEAT F.P.	B CORN F.P. 4	C OATS D	A OATS S.P.	B CORN F.P. 4	C OATS D	A OATS F.P.	B CORN F.P. 2	C WHEAT S.P.
A OATS F.P.	B CORN F.P. 6	C BARLEY D	A CORN S.P.	B WHEAT D	C ALFALFA 42	D ALFALFA	E ALFALFA	F OATS F.P.	A WHEAT S.P.	B CORN S.P. 9	C OATS S.P.	A OATS F.P.	B CORN F.P. 1	C WHEAT D.	A OATS F.P.	B CORN F.P. 2	C WHEAT S.P.
A OATS	B CORN F.P. 46	C CORN S.P.	A CORN S.P.	B CORN F.P. 44	C WHEAT D	D ALFALFA	E OATS	F OATS	A BARLEY S.P.	B CORN S.P. 7	C OATS S.P.	A OATS F.P.	B CORN F.P. 3	C WHEAT F.P.	A OATS F.P.	B CORN S.P. 3	C WHEAT D.
A CORN S.P.	B WHEAT D 16	C PARS F.P.	D OATS	B BARLEY F.P.	A BARLEY S.P.	B WHEAT F.P.	C FALLOW 8	D OATS F.P.	A OATS S.P.	B CORN F.P.	C CORN S.P.	A OATS F.P.	B CORN F.P. 43	C WHEAT F.P.	A OATS F.P.	B CORN S.P. 50	C FALLOW
A CORN S.P.	B WHEAT D 14	C RYE F.P.	D OATS	D FALLOW	E BARLEY	D FALLOW	E WHEAT	D FALLOW	C OATS	D FALLOW	C CORN	A OATS	B CORN S.P. 50	C FALLOW	A OATS F.P.	B FALLOW 5	C WHEAT
A CORN S.P.	B WHEAT D 12	C FALLOW	D OATS	A CORN S.P.	B WHEAT D 12	C FALLOW	D OATS	A OATS S.P.	B CORN F.P. 47	C CANE S.P.	A OATS S.P.	B CANE S.P. 48	C WHEAT S.P.	A OATS F.P.	B FALLOW 5	C WHEAT	

FIELD 41

S.P. SPRING FLOWING
F.P. FALL FLOWING
D DISKED IN PREPARATION
FOR SEEDING

Chart I.—Plat A Rotation 44—Cane.

SPRING WHEAT.

Table 1 shows the annual and average yields of spring wheat from 1907 to 1914 inclusive, under different methods of tillage and crop sequence. Where wheat has been grown on more than one plat in the same manner, the average yield of all such plats has been used. Plowing has been done at an average depth of about eight inches, except on one plat where wheat has been continuously grown on spring-plowed land. In this case the depth of plowing has been four inches. Under the column headed "Green Manure," wheat follows winter rye and Canada field peas, which were plowed under when a maximum growth had been reached, usually about blooming time.

Small-grain stubble that is to be plowed in the spring in preparation for wheat is usually disked once in the fall to prevent the growth of weeds. In the one exception to this, where continuous cropping is practiced, the stubble is left untouched until the time of plowing. Where fall plowing is practiced under the same system of cropping, one or two diskings follow the harvest operations as soon as possible.

In the practice of summer tillage the land is plowed once, usually in the fall. Such cultivation as is necessary to keep the land free from weeds and the surface in a condition receptive to rainfall then follows until seeding time the second spring. This method of clean summer tillage may be regarded as intensive.

It will be noted from the table that three profitable crops have been produced during the eight years. One year resulted in a total failure due to drouth and some injury from grasshoppers. The remaining four years are far below the point of profitable production. Between the general averages for the production of wheat on fall-plowed land and spring-plowed land the difference is less than 1 bushel per acre. Where continuous cropping is practiced the difference between the average yields on spring- or fall-plowed land is only one-half bushel per acre. Wheat on fall-plowed corn land has averaged 1.8 bushels more than wheat on spring-plowed corn land. Fall-plowed oats stubble has yielded 1.5 bushels more wheat than spring-plowed oats stubble. Wheat on spring-plowed oats stubble has given the lowest yield of any method used in producing wheat during the eight years. The average yield from this method, 9.6 bushels per acre, is 2.6 and 1.5 bushels per acre less than wheat following wheat on fall- and spring-plowed land, respectively. Further study of this method shows that in only one year, 1910, has wheat following oats on spring-plowed land given a higher yield than wheat on spring-plowed wheat land. The difference in this case was only 1.9 bushels per acre.

Altho wheat on spring-plowed sorghum stubble has given the next lowest average yield, it is only 0.1 of a bushel per acre less than wheat on spring-plowed corn land. Further study of the table by years shows that wheat under this method has yielded often as much and during some years more than wheat following corn, wheat, or oats, on spring- or fall-plowed land.

Wheat on disked corn stubble has averaged 0.2 of a bushel more per acre than wheat on spring-plowed corn land and 1.6 bushels less than wheat on fall-plowed corn land. When the cost of producing wheat on disked corn stubble is considered, it is evident that this method is more conducive to profitable results than producing wheat on either spring- or on fall-plowed corn stubble or on plowed small-grain stubble.

The yields of wheat have been increased by the practice of summer tillage more than by any other method, but the increase in yield has not been large enough to offset the increased cost of production and to return a fair margin of profit to the farmer. This method did not prove to be an absolute safeguard against drouth in 1911, when wheat failed entirely under all methods of crop production.

During the year of 1909, it will be seen that spring wheat on land previously fallowed did not yield as much as wheat on spring-plowed wheat land. This was due to the poor stand obtained on the fallowed plat. Conditions for germination were not as favorable in the spring-plowed plat as in either the fall-plowed or the fallowed plat. Consequently, the grain on the spring plowing came up slowly and escaped a freeze that severely injured the grain on the other plats.

The results secured in 1912 vary from the average more than those of any other year. The highest yield, 14.2 bushels per acre, was secured from land on which rye had been turned under for green manure. The yield from the corresponding plat on which peas had been turned under for green manure was only 4.8 bushels. Spring- and fall-plowed wheat land produced yields of 12.8 and 11.2 bushels per acre, exceeding the yields of summer-tilled land by 5.6 and 4.0 bushels per acre, respectively. In this year the difference in moisture in the first 4 feet between plats receiving various treatments was very small at seeding time. The inconsistent single year results call attention to the necessity of having results which extend over a number of years from which to draw conclusions.

These eight years' results do not show any very wide differences as far as average yields are concerned. But, as will be shown later, there is considerable variation in profits per acre, due to the difference in cost of production by various methods of tillage.

TABLE 1.—*Yield of spring wheat from different methods of seed-bed preparation and crop sequences. Bushels per acre. Eight years, 1907-1914.*

Preparation of seed bed	Previous crop	No. of plats	1907	1908	1909	1910	1912	1913	1914	Average 8 years ¹
Fall plowed	Corn	2	22.5	28.7	21.3	7.6	6.4	4.1	5.5	12.0
	Oats	2	26.3	27.3	16.0	6.8	4.7	1.3	6.1	11.1
	Wheat	1	26.0	27.3	16.3	6.7	11.2	1.8	5.2	11.7
	Average	5	24.7	27.9	18.0	7.1	6.7	2.5	5.7	11.6
Spring plowed	Corn	1	23.7	24.0	17.2	5.2	5.3	1.5	5.0	10.2
	Oats	1	20.8	17.5	16.7	8.7	8.8	1.8	2.2	9.6
	Wheat	1	24.5	22.7	23.0	6.8	12.8	2.0	6.0	12.2
	Sorghum	1	23.5	20.3	16.3	8.7	3.8	3.3	5.2	10.1
	Average	4	23.1	21.1	18.3	7.4	7.7	2.2	4.6	10.6
Disked	Corn	8	24.5	24.2	14.5	7.3	4.6	3.0	5.1	10.4
Summer tilled		3	28.9 ⁴	41.4 ⁴	22.6 ⁴	16.3	7.1	6.8	12.5	17.0
Average of all plats			24.7	26.3	17.1	8.2	6.1 ²	3.28 ³	6.0	11.5

¹Wheat was an entire failure in 1911, but this year is included in the average.²Average of 22 plats.³Average of 23 plats.⁴Average of 2 plats.

CORN.

Corn has occupied a rather important position in this study of crop production in western Nebraska. Altho the grain itself has been uncertain in production, experience shows that a fairly good quality of stover may be produced each year. If the maximum feed value of the stover is obtained, the value of the crop is greatly increased. In addition to its feed value, the crop lends itself well to the preparation of the land for the succeeding crop. Such a combination of two valuable factors in one crop adds greatly to the importance of its growth. It is very evident also that corn becomes most valuable in a system of farming where live stock is produced. Potatoes have an effect on crops that follow similar to that of corn, but are not so well adapted as corn to growth on a large acreage.

The effect of the growth and the clean cultivation of corn upon following crops approaches more nearly the effect of summer tillage than in the case of any other crop. This may be readily seen in the study of the tables showing the production of spring wheat and oats under different methods of tillage and crop sequence. Frequently the yields of small grain following corn have been higher than any others obtained except those on land previously summer tilled. Even where the yields have not been the highest, they have approached the highest so closely that they have produced the most net profit when the cost of seed-bed preparation is considered. Altho corn has had an important place in the preparation of the land for other crops a study of different methods of growing the crop itself is highly important.

A study of the production of corn as presented in Table 2 shows the effects of the cropping or the tillage of the land in the one year only preceding the corn. This table presents the annual and average yields for eight years, 1907 to 1914 inclusive. Where corn follows corn on spring-plowed land and on fall-plowed land, a system of continuous cropping is practiced. When continuous cropping is practiced on land that is fall plowed, the land is given sufficient tillage in the fall and early spring to insure the storage of a maximum amount of the precipitation that falls in the meantime. In the practice of continuous cropping on spring-plowed land, the soil is plowed to a depth of only about 4 inches and followed by a limited amount of cultivation.

Where corn is produced on land that has been summer tilled, a system of alternate cropping and summer tillage is practiced; that is, the land is cropped to corn one year and summer tilled the next.

Where corn follows oats on spring plowing, it is the second crop after sod in two six-year rotations where alfalfa and brome grass are grown. Altho the yields are presented in such a manner as to show the residual effect of a sod crop, the real object of the method has been defeated. Yields of brome grass and alfalfa have been obtained in two years only, 1907 and 1908. The land has been reseeded since that time, according to the plan of a six-year rotation of corn, spring wheat, oats, and brome grass or alfalfa, but permanent stands of grass have not been secured. Because of the failure to secure permanent stands of grass, the yields of corn under this method will not be discussed.

In view of the fact that we know that alfalfa and brome grass use the moisture in the soil to a lower depth than any of our grain crops, it is reasonably safe to assume that grain crops cannot follow these hay crops successfully until water has been stored in the soil. The length of time required to do this will depend upon the amount and character of the annual or seasonal precipitation.

Corn has always been planted about May 10 with the lister at the rate of one to two grains every 18 or 20 inches. Former experiments reported from this Station show the advisability of using the lister in preference to the surface planter.

The variety of corn used is commonly known as white dent, originally Silver Mine, which has been reduced to a medium size. This variety is well adapted to the country surrounding North Platte and is early enough to insure maturity.

The corn is harvested with the binder when mature, and shocked in the field. The shocks stand until cured, which is usually about one month or six weeks. The entire weight is then taken, and the grain is shucked and weighed separately. The unit basis for the weight of the grain is 70 or 75 pounds per bushel, depending upon the dryness at the time of husking.

During the eight years that corn has been grown under different methods of tillage and crop sequence, four fairly profitable crops of grain have been produced. Two years resulted in failures and the remaining two years were more conducive to loss than to profit. The final average for eight years indicates that there is very little profit in growing corn for the grain alone by the most favorable of the methods under study and no profit when grown by the less favorable methods, but these results also indicate that fair profits may be secured from almost any of these methods if the stover as well as the grain is utilized. The annual and average yields of stover for eight successive years show that the stover has produced a profitable and dependable crop of forage. This factor alone will seriously affect the profit

or loss from the corn crop. The necessity of producing forage for the maintenance of live stock in this country makes the highest utilization of the entire crop a very important factor.

A close study of soil-moisture¹ determinations during the eight years that these methods have been in progress indicates fairly conclusively that corn does not use the soil moisture to such a close margin or altogether as deep as does small grain. On fall-plowed ground, corn following oats has averaged 1.1 bushels per acre more than corn following spring wheat. But on spring plowing the same sequence of crops has had no effect on the average yields. Corn following barley on fall-plowed land has given a slightly better average yield than corn following spring wheat or oats. The difference, however, is slight.

The practice of growing corn on land previously summer tilled has increased the yields of grain but little. The yields of stover have been increased slightly. However, neither the increased yields in grain nor in stover have been large enough to offset the increased cost of production or to pay a profit from any point of view. Corn grown on land previously summer tilled has averaged only 2.3 bushels per acre more than corn grown under a system of continuous cropping on spring-plowed land and 2.6 bushels more than corn grown under the same system of cropping on fall-plowed land. Continuous cropping of corn on fall-plowed land has given an average yield of 0.3 of a bushel per acre less than continuous cropping of corn on spring-plowed land. Spring plowing has given the best average returns of corn of any method under study.

A careful survey of Table 2 would indicate that corn should be grown for a feed crop rather than as a cash crop alone. As a feed crop, it is probably safer than any of the small grains. If a small-grain crop is destroyed before maturity by severe weather conditions, the plant growth already developed is practically lost so far as feed is concerned. But corn has the advantage in that it may usually be cut and handled in such a way that considerable feed is saved if weather conditions threaten to destroy the crop. In case the crop is destroyed by hail, corn land may be prepared for the use of emergency crops to better advantage than small-grain land.

¹See Bulletins 109 and 114 and Research Bulletin 5 of this Station for more complete data on soil moisture.

TABLE 2.—Yield of corn from different methods of seed-bed preparation and crop sequences. Bushels of grain and pounds of stover per acre. Eight years, 1907-1914.

Preparation of seed bed	Previous crop	No. of plots	1907		1908		1909		1910		1911		1912		1913		1914		Average	
			G ¹	S ²	G	S	G	S	G	S	G	S	G	S	G	S	G	S	G	S
Fall plowed	Corn	1	27.7	4,360	24.6	2,630	31.6	2,790	6.2	2,500	580	39.9	2,330	1,780	15.5	2,060	18.2	2,388	18.2	2,388
	S. wheat	2	16.7	4,570	25.9	3,023	26.3	2,365	3.3	1,100	680	22.9	2,860	1,280	2.0	1,185	12.3	2,019	12.3	2,019
	Oats	7	18.2	3,523	21.8	3,177	25.0	2,361	2.4	1,223	819	27.0	2,226	1,614	4.3	1,586	13.4	2,074	13.4	2,074
	Sorghum	1	18.7	3,773	21.9	3,420	27.6	3,370	1.0	890	710	26.6	2,420	1,620	4.3	1,020	10.1	2,079	10.1	2,079
	Average	.....	19.7	4,448	25.7	3,124	26.7	2,486	2.8	1,290	790	26.7	2,183	1,514	4.7	1,470	13.1	2,221	13.1	2,221
Spring plowed	Corn	1	28.7	4,680	38.6	3,250	29.0	2,470	8.9	2,440	980	34.1	2,340	1,740	8.5	1,600	18.5	2,438	18.5	2,438
	S. wheat	1	18.6	4,930	28.0	3,490	27.1	2,310	8.3	1,250	1,050	28.4	2,510	1,540	2.0	1,300	13.9	2,411	13.9	2,411
	Oats	5	21.6	4,354	24.9	3,340	24.4	2,312	6.3	1,762	712	26.3	2,834	1,542	3.9	1,208	13.9	2,262	13.9	2,262
	Barley	1	22.6	4,590	31.7	3,630	22.1	2,945	6.2	1,810	970	28.3	2,880	1,270	4.0	1,050	14.5	2,406	14.5	2,406
	Oats on seed rotation	2	14.9	5,095	16.1	3,675	25.6	2,830	3.4	1,415	485	21.3	2,550	1,525	1.5	1,005	10.8	2,323	10.8	2,323
Summer tilled	Average	.....	20.8	4,616	25.5	3,442	26.1	2,599	6.1	1,714	769	26.8	2,695	1,527	3.8	1,200	13.6	2,320	13.6	2,320
	Average	.....	17.9	4,920	38.2	3,530	25.0	2,300	21.9	3,300	930	35.1	2,340	2,240	27.9	2,130	20.8	2,711	20.8	2,711
Average			20.1	4,546	25.2	3,287	26.4	2,529	5.2	1,574	782	27.1	2,423	1,563	5.0	1,380	13.6	2,277	13.6	2,277

¹No grain was produced in 1911 and 1912, but these years are included in the average.²G., Grain.³S., Stover.

OATS.

In Table 3 eight years' results in the production of oats are presented. The data shown in this table are presented in the same manner as those for spring wheat and corn in Tables 1 and 2. Where oats follow oats on spring- and fall-plowed land the explanations are the same as those for spring wheat and corn.

Kherson oats have been used continuously in this work. The seeding has been done with the press drill at the rate of 6 pecks per acre and at the same time as the seeding of the other spring small-grain crops. Altho large and profitable yields of oats have been produced, it was only during years that were very favorable to crop production. Later years tend to show that oats do not have much ability to withstand severe seasonal conditions. As yet, none of the many methods of tillage that have been tried have been able to overcome this unfavorable characteristic of the oat.

Referring to the yields of oats under different methods of tillage and systems of cropping, in Table 3 it will be seen that the three years 1907, 1908, and 1909 were productive of good yields of oats. Since that time, the crops have been very light, with two absolute failures. Altho yields were obtained in 1910, 1912, and 1914, the grain was very light and chaffy. During these three years, especially 1910 and 1914, it would have been more practical to cut the crop for hay, rather than to let the grain mature and be threshed as a grain crop.

Closer study of this table shows that seasonal variations have produced much larger differences in yields than methods of tillage and systems of cropping. During the years favorable to the production of small grains all cultural methods produced good crops. During the years when weather conditions were severe or extremely unfavorable none of the cultural methods were able to return a profit in the form of either a feed crop or a cash grain crop. Continuous cropping of oats on fall-plowed land has given the largest average yield, and oats following barley on fall-plowed land has given the lowest average yield of any system of cropping in use. Only once (1912) during the eight years has continuous cropping of oats yielded less than oats following barley. During the remaining seven years the difference has been distinctly in favor of the system of continuous cropping. Where oats follow spring wheat, the yields have been constantly less, and, on the average, 3.6 bushels per acre less than the yields resulting from the practice of continuous cropping.

Spring wheat stubble that had been manured before the land was plowed in the fall has averaged 2.1 bushels more of oats per

acre than spring plowed land that was not manured. During the eight years that these methods have been under study, manuring the land has failed to equal or increase the yield in the two seasons of 1904 and 1914.

The practice of continuous cropping of oats on spring-plowed land has averaged 4.4 bushels per acre less than the same method on fall-plowed land. Oats on spring-plowed spring wheat stubble have yielded better than oats on fall-plowed spring wheat stubble in five years out of six that have produced crops, but the great difference in favor of fall-plowed wheat stubble in 1908 has reduced the average increase from spring plowing over fall plowing to 0.7 of a bushel per acre for 8 years. Oats on spring-plowed spring wheat land have given practically the same average yield as oats on spring-plowed corn land. These two systems of cropping have given the highest average yield of oats of any of the spring-plowed land.

It would seem that on the average the time of plowing does not affect the yields of oats. An average difference of only 0.7 of a bushel per acre is found in favor of spring plowing over fall plowing. This would indicate that the land should be plowed for oats when the work can be done most economically, provided such tillage will not result in damage from soil blowing or from other causes.

The average yield of oats on disked corn ground, 17.9 bushels per acre, is practically the same as the average yield of oats under all methods of production on both spring- and fall-plowed land. This is by far the cheapest method of production and should find favor in a system of farm management where oats are given much consideration.

Summer tillage has increased the yields of oats more than any other method of tillage, but the increase in yields has not been sufficient to pay for the increased cost of production when compared with other methods. Altho the practice of summer tillage has given the greatest increase in the yields of oats, it failed entirely to produce yields in 1911 and 1913.

Where winter rye or Canada field peas has been used for a green-manure crop as a seed-bed preparation for oats, the yields have been increased more than by any other method except summer tillage. Oats following alfalfa and brome grass as sod crops have given the poorest returns of any system of cropping that has been under study.

The average production of oats for eight years under all methods of tillage and crop sequence is 19.8 bushels per acre. With the exception of the first three years the grain has been very light and chaffy. A comparison of oats with other small-grain crops during the eight years of production indicates rather definitely that oats have produced less feed or profit per acre than any other crop.

TABLE 3.—Yield of oats from different methods of seed-bed preparation and crop sequences. Bushels per acre. Eight years, 1907-1914.

Preparation of seed bed	Previous crop	No. of plats	1907	1908	1909	1910	1912	1914	Average 8 years ¹
Fall plowed	S. wheat	3	29.6	58.4	23.2	8.2	9.4	8.2	17.1
	Manured	1	35.0	68.5	28.1	4.4	10.6	7.2	19.2
	S. wheat	1	36.0	68.5	24.1	11.9	10.6	14.7	20.7
	Oats	1	23.1	49.1	20.0	6.6	14.7	10.0	15.4
	Barley	1	30.5	60.2	23.6	7.9	10.7	9.4	17.8
Spring plowed	Average	.....	.....	.....	.....	.....	.....	.....	.....
	S. wheat	2	34.5	47.7	32.8	12.5	18.6	9.1	19.4
	Oats	1	30.0	34.4	31.3	11.3	18.7	5.0	16.3
	Corn	2	34.6	54.3	31.3	12.2	14.4	9.7	19.6
	Sorghum	1	30.0	45.0	28.8	8.1	12.5	7.8	16.5
Disked	Average	.....	.....	.....	.....	.....	.....	.....	.....
	Corn	1	40.6	53.4	22.5	11.9	6.6	7.8	17.9
Summer tilled	.....	.....	.....	.....	.....	.....	.....	.....	.....
	.....	4	34.3	87.1	37.3	26.2	19.6	14.9	27.4
Green manure	Rye	2	30.5	73.8	32.5	16.4	10.3	10.0	21.7
	Peas	2	28.5	75.8	34.8	14.6	13.8	9.7	22.2
	Average	.....	.....	.....	.....	.....	.....	.....	.....
Sod	Alfalfa	1	24.0	36.8	14.4	2.5	12.5	7.2	12.2
	Brome grass	1	22.2	40.0	16.6	4.7	7.2	5.6	12.0
	Average	.....	.....	.....	.....	.....	.....	.....	.....
Average of all plats	.....	.....	.....	.....	.....	.....	.....	.....	.....
	.....	.....	31.4	61.8	28.4	13.1	13.7	9.8	19.8

¹Oats were an entire failure in 1911 and 1913, but these years are included in the average.

BARLEY.

Barley continuously cropped on fall-plowed land has averaged 1.4 bushels per acre more than barley continuously cropped on spring-plowed land. On spring-plowed land it does not seem to make any difference whether the land was previously cropped to oats or barley. Barley grown on disked corn land has averaged less for eight years than when grown by any other method. Of the seven crops that were produced, only two on disked corn ground were as good as those produced on small-grain stubble that had been plowed either in the spring or in the fall. Barley has not given as profitable returns on disked corn land as spring wheat. Land that was previously summer tilled increased the average yield of barley but did not increase the profit per acre. In 1907, the practice of summer tillage did not increase the yields of barley as compared with other methods except disked corn land. In 1911, the practice of summer tillage failed as completely to produce a crop as any other method under trial. In 1912, the returns of barley from continuous cropping on spring-plowed land and from barley following oats under the same tillage were as large as from barley grown on land previously summer tilled.

SORGHUM.

Sorghum has been grown as a forage crop in certain rotations. It has been seeded with a press drill at the rate of 5 pecks per acre. The average annual yield for seven years has been 3.1 tons per acre. Spring wheat land that was manured and plowed in the spring has given an average yield of 459 pounds less of sorghum hay per acre than spring-plowed oats land with no manure applied. Corn land that was manured and plowed in the spring has yielded only 148 pounds more of sorghum hay per acre than the manured oats land. Such yields would indicate that manure has not had any beneficial effect on the sorghum crop nor has it left any apparent residual effect on succeeding crops. During favorable seasons and also under drouth conditions sorghum has given a larger tonnage per acre than any other crop. The feeding value of sorghum, as reported in Bulletins 105 and 117 of this Station, is about the same as that of native hay.

TABLE 4.—Yield of barley from different methods of seed-bed preparation and crop sequences.
Bushels per acre. Eight years, 1907-1914.

Preparation of seed bed	Previous crop	No. of plats	1907	1908	1909	1910	1912	1913	1914	Average 8 years ¹
Fall plowed.....	Barley.....	1	40.0	43.3	10.4	12.5	14.6	5.0	11.0	17.1
Spring plowed.....	Barley.....	1	39.0	19.6	21.5	13.8	20.8	6.5	5.3	15.8
	Oats.....	1	40.2	22.3	18.6	16.0	20.0	6.3	3.6	15.9
	Average.....	2	39.6	21.0	20.1	14.9	20.4	6.4	4.5	15.9
Disked.....	Corn.....	1	30.6	24.9	21.5	7.9	12.3	5.0	5.2	13.4
Summer tilled.....	.....	1	39.0	67.7	23.8	26.0	20.0	16.5	20.8	26.7
Average of all plats.....	.....	5	37.8	35.6	19.2	15.2	17.5	7.9	9.2	17.8

¹Barley was an entire failure in 1911, but this year is included in the average.

SPRING AND FALL PLOWING.

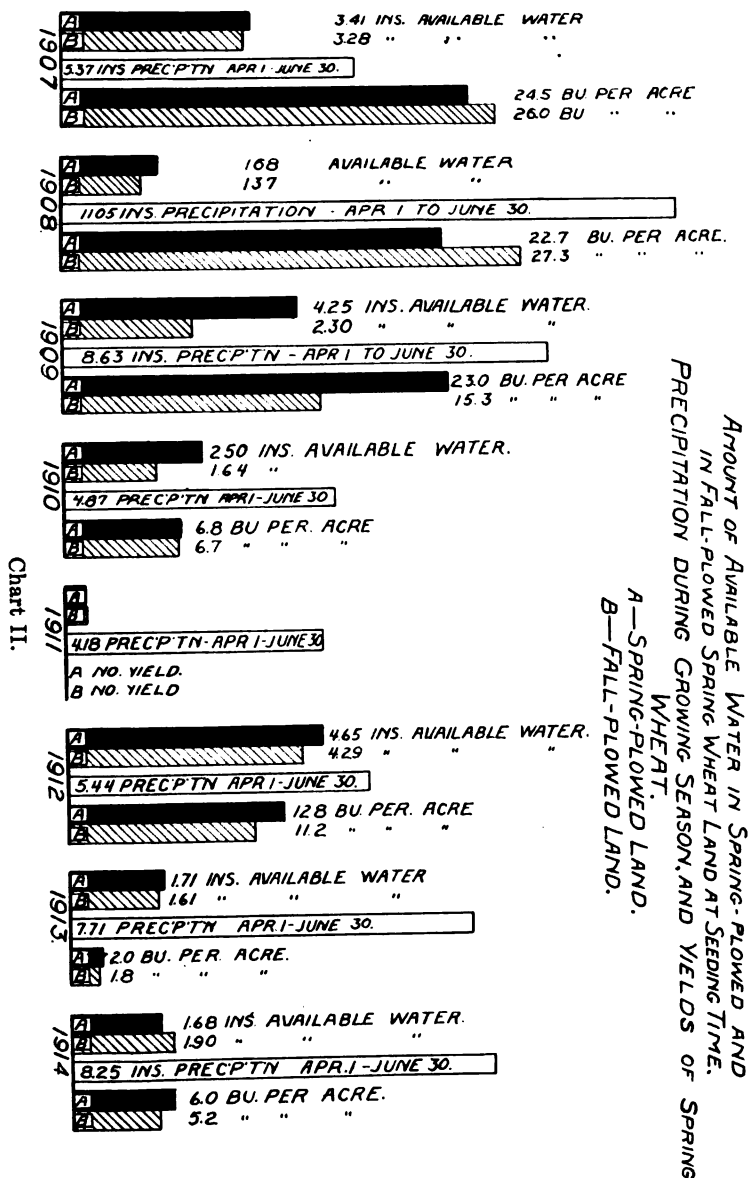
From the standpoint of average yield but little difference has been observed in the production of spring wheat, oats, barley, and corn on fall-plowed land or on spring-plowed land. When the net profit per acre is considered in the production of wheat, spring plowing has been the more profitable. Altho oats have returned a very small margin of profit in various rotations on spring- and on fall-plowed land, they have more frequently resulted in a loss under both methods of tillage. Neither spring- nor fall-plowed land has returned more than a few cents per acre net profit in the production of barley. Both methods of tillage have given practically the same results in the production of corn.

That spring plowing has been more profitable, so far as profit per acre is concerned, is largely due to the fact that the cost of production on spring-plowed land is less than on fall-plowed land, owing to fewer field operations being required to put the spring-plowed land into condition for seeding. However, this advantage may be overcome by employing labor for fall plowing that would otherwise be idle.

Chart II is presented to compare the efficiency of fall-plowed land with that of spring-plowed land in the storage of moisture in the soil. The principal fact brought out by this chart is that during four years out of seven under study, there has been more moisture at seeding time in the first three feet of spring-plowed land than in the same depth of fall-plowed land. During the three years that spring-plowed land contained less moisture than fall-plowed land, the difference was practically negligible. The amount of water that can be stored in the soil from the harvest period of one crop to the seeding time of the next crop is comparatively small except in very favorable years when the amount of rain or snow during this period is above normal and of such character that there is but little run-off. Under conditions that have prevailed during the last five years, this stored moisture is rapidly used by weeds and the growing crop in the spring.

DISKED CORN STUBBLE LAND.

Disking corn stubble land as a method of seed-bed preparation has given practically as good results from the standpoint of yields in the production of small grain, except barley, as either spring or fall plowing. The cultivation of the soil while the corn was growing kept the land free from weeds and left the soil in such condition that it could be made into an excellent seed bed easily and quickly by the disk in the spring. The low cost



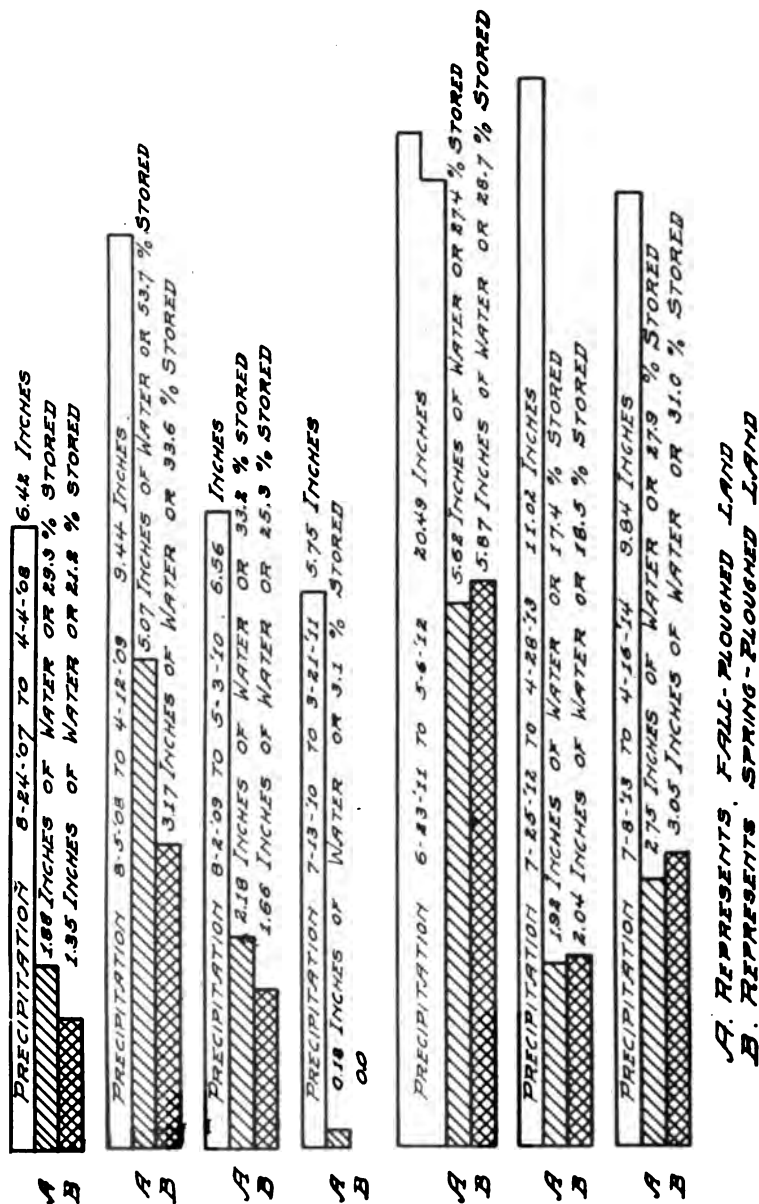


Chart III.—Storage of moisture in spring-plowed and in fall-plowed land.

of such field operations has resulted in more net profit per acre in the production of spring wheat and oats than any other method. Even tho barley on disked corn land gave the lowest average yield of any method under trial, the cost of production was low enough to permit this method to return the most net profit of any method for an average of eight years.

SUMMER TILLAGE¹.

Land summer tilled has produced higher yields of spring wheat, oats, barley, and corn than any land cropped every year, but has not returned as much net profit per year as land farmed by other methods. Summer tillage has not overcome the effect of a severe drouth, nor always produced larger yields than land that was cropped each year. Spring wheat on land summer tilled did not yield as much as spring wheat on spring-plowed land in 1909. Land summer tilled failed to produce a grain crop in 1911, the same as land that was cropped each year. In 1912, spring wheat on land summer tilled averaged 5.6 bushels per acre less than wheat on spring-plowed land cropped each year, and 4 bushels less per acre than wheat on fall-plowed land cropped each year. In 1913, barley and corn failed to produce grain crops on land summer tilled as well as on similar land cropped each year.

The average yield of spring wheat on all the plats cropped every year has been 10.9 bushels per acre. The average yield of spring wheat following corn has been 12 bushels per acre. The average yield of spring wheat following spring wheat on spring-plowed land has been 12.2 bushels per acre. The average yield of spring wheat on land summer tilled has been 16.8 bushels per acre, or 4.2 bushels per acre more than that grown by the most productive method of continuous cropping. This increase in yield due to summer tilling the land has not been large enough to overcome the additional cost of raising a crop on land summer tilled. A study of the results given in Table 7 indicates that this is true also of corn, oats, and barley. Next to the use of winter rye and Canada field peas as green manure for seed-bed preparation, the practice of summer tilling land is the most expensive method under trial.

Clean summer tillage is the most practical method known of accumulating moisture in the soil. But Chart IV indicates that only a small part of the precipitation may be stored in the soil. The condition of the soil, the amount of water falling within a

¹A more complete discussion of summer tillage and the use of soil moisture is given in Bulletins 109 and 114 and Research Bulletin 5 of this Station.

given time, and the weather conditions all play important parts in determining the percentage of the season's precipitation that may be stored. The seasonal distribution of rainfall and the weather conditions during the growing period have a greater influence on the yields of the crops than has the amount of water stored in the soil. Small-grain crops have been able to use all of the moisture stored by summer tillage, in addition to the precipitation coming during the growing season.

ROTATIONS¹.

In studying the profit or loss of various rotations, all factors entering into each rotation should be given due consideration. The cause of a loss in a certain rotation may be due to some factor that might be eliminated in actual farm practice. For example, corn is grown on spring-plowed land in many of the rotations. Common practice indicates that in this locality as good yields might be secured at less cost by disking instead of plowing. This would give corn a higher place in common farm practice than is indicated in Table 7. In some rotations manure has been added at a high cost, tho there is no indication that the manure increased the yield. As two of the rotations having sorghum as one of the crops also have manure added, they are lower in net returns than necessary.

A careful survey of Table 7 shows that nearly all rotations giving a loss were designed to maintain the soil fertility by barnyard manure, a green-manure crop, or a grass crop. The other final items of loss occur where corn was grown on land summer tilled, where oats were grown continuously on spring-plowed oats land or on land summer tilled, or where barley was grown on land summer tilled.

The rotations giving an annual net profit of less than \$1 per acre all contained summer tillage as a regular practice once in three or four years, except two rotations in each of which the ground was prepared for corn by plowing instead of by disking, which increased the cost about \$1 per acre, probably, without increasing the yields.

There was no rotation in which the crops were grown according to common farm practice conducted thoroly that did not give an average annual profit of more than \$1 per acre.

If we should assume that the barnyard manure did not materially increase the succeeding crop of sorghum, and we believe it did not, then the most profitable rotation of the entire series

¹See Table 7, page 35.



Chart IV.—Storage of water by clean summer tillage. 1907 to 1914.

is sorghum, corn, and spring wheat. In this, corn stover is given a value of \$3 per ton and sorghum a value of \$4 per ton.

Rotations of oats, corn, and spring wheat rank high in the profit per acre. The oats are usually the unprofitable crop in these rotations. As a single crop, corn ranks above any of the small-grain crops in the profit returned where the stover and grain are both used. The effect of corn in leaving the field in a suitable condition for the succeeding crop should add to the value of the corn crop in a rotation. Spring wheat ranks next to corn in the rotations. It gives the greatest profit where it follows corn.

The results of this work to date commend the common tillage practices of the farmers thruout this region in so far as these practices are conducted in an intelligent and thoro manner.

CROP SEQUENCE.

Continuous cropping of spring wheat has given an average yield practically as large as that obtained from corn land. Where spring wheat follows sorghum grown for forage, the average yield has not been noticeably diminished when compared with spring wheat following either corn or spring wheat. Where spring plowing is practiced, spring wheat following oats has given the lowest average yield of any crop sequence for wheat. This difference, however, has not resulted where the oats land was plowed in the fall. On fall-plowed land, continuous cropping of corn has averaged 4.9 bushels per acre more than corn following small grain, and on spring-plowed land a difference of 5.3 bushels per acre has favored the system of continuous cropping. Corn following sorghum has given the lowest average yield for eight years of any crop sequence for corn.

Oats following brome grass or alfalfa has been the lowest yielding sequence for oats for an average of eight years. On fall-plowed land, the highest average yielding sequence for oats has been continuous cropping of oats and the lowest average yielding sequence has been oats following barley. On spring-plowed land, continuous cropping of oats and oats following spring wheat and corn have given the highest average yields. The differences in yield between any of the various crop sequences for oats, except oats following barley, are so small that they may be reversed by one favorable crop year.

Barley grown on disked corn land has given the lowest average yield of any crop sequence for barley. Barley following oats has given practically as good results as continuous cropping of barley.

BARNYARD MANURE.

Barnyard manure has been applied to certain plats once in three years at the rate of about 10 tons per acre. In Rotation 43 of oats, corn, and spring wheat, all seeded on fall-plowed land, the manure was applied before plowing for oats. In Rotation 3 the same crops were grown in the same manner except that no manure was used. The value per acre annually of the crops from the rotation not having manure is \$1.78 more than the value of the crop from the rotation having manure.

The other rotations in which manure is used are 44 and 47 in both of which grain stubble is manured during the winter and spring plowed for sorghum. There is no rotation differing from either of these rotations in manure alone, but Rotation 48 is somewhat similar and may assist in ascertaining the value of manure. The eight-year average yield of sorghum hay from the plat in Rotation 44, where sorghum was grown on manured wheat stubble, was 5,856 pounds per acre yearly. In 47 the corresponding yield was 6,464 pounds, or the average of the two plats manured was 6,160 pounds. In Rotation 48, where sorghum followed oats and preceded wheat without any manure in the rotation, the average annual yield for the eight years was 6,316 pounds. There is no indication that the barnyard manure increased the yield of sorghum forage.

Altho the manure has undoubtedly maintained or increased the fertility of the soil, it has given no appreciable beneficial effect on the yield of the succeeding crops. However, it should not be inferred that the application of barnyard manure is to be condemned. Generally the manure can be applied when there is little demand for the labor of men and teams. Also the cost of spreading manure on the land is not very different from the cost of dumping it into a ravine.

It is pretty definitely understood that water is the limiting factor in crop production in the Great Plains area. Organic matter, if properly applied to the soil, increases the efficiency of the water in the soil and tends to keep the soil in a good physical condition. Since the history of land farmed longer shows that the soil will eventually reach a point of diminishing returns unless plant food is returned to the soil thru application of barnyard manure or some other form of fertilizer, it would seem advisable not to waste the barnyard manure even tho the succeeding yields as recorded in this bulletin do not show any beneficial effect from its use.

GREEN MANURE.

During the three years in which spring wheat has been grown on land where winter rye and where Canada field peas have been plowed under to serve as green manure, the yields have not been greatly increased over those of ordinary methods of production. Oats have given a response in yield to green manure next to that obtained by the practice of summer tillage.

No practical difference has been noted between the results from the use of rye and peas as green-manure crops. The use of green-manure crops has proved to be even more expensive and less profitable than alternate cropping and summer tillage. Tho the yields have been increased by the green-manure crop, the additional cost of producing the crop, as represented by the rental of the land an extra year, the cost of the seed for the green-manure crop, and the extra tillage that must accompany this method, are so great that the final profit from this method of production is not as great as from ordinary methods.

ALFALFA AND BROME GRASS.

Alfalfa and brome grass are each used three years in six-year rotations. The purpose of these rotations is the production of forage crops and the maintenance of soil fertility. During five years out of eight neither the alfalfa nor the brome grass has produced any forage. Since 1911 a permanent stand has not been secured of either. It is evident that neither of these forage crops has been used successfully in these rotations.

COST OF PRODUCTION.

Since the cost of production is an important factor in determining the profits to be derived from any system of farming, it seems advisable to present data to furnish information on this point. In order to arrive at the cost of various methods, it is necessary to assign values to all operations and products. Some of these values are necessarily somewhat arbitrary, but all factors have been given careful consideration and the values are thought to be fairly representative for this region and sufficiently accurate to make comparisons reliable. By the use of the data presented here the farmer may adjust values according to his local conditions and get a fair conception of the net returns that may be expected under his management.

In computing the cost of various operations, a fixed wage of \$2 per day for a man and \$1 per day per horse has been used. Factors included in the cost of production are calculated on an acre basis for each of the separate operations performed, beginning with the preparation of the land and ending with the harvest-

ing and the shocking of the grain. To these are added the price of the seed and interest, and the taxes on land investment calculated at 8 per cent on a valuation of \$20 per acre. Fifteen cents per acre is also allowed for deterioration and repairs on the binder. But no allowance has been made for deterioration on other machinery, as it is believed that the wages allowed for men and teams is sufficient to cover this item for the remainder of the equipment.

The average farm prices of the various grains during the past 10 years, according to the Bureau of Crop Estimates of the United States Department of Agriculture, were: Oats 35 cents per bushel, spring wheat 80 cents per bushel, barley 47 cents per bushel, and corn 51 cents per bushel. It will cost to take the grain from the shock, thresh or shell, and put it into the bin about 5 cents per bushel for oats, 10 cents per bushel for spring wheat, 6 cents per bushel for barley, and 11 cents per bushel for corn. Subtracting these costs from the farm prices as shown above, it is evident that the grain would be worth in the shock the following prices: Oats 30 cents, wheat 70 cents, barley 41 cents, and corn 40 cents per bushel. The presumption in this bulletin is that corn is grown for the forage as well as for the grain and that, therefore, it is cut and the ears shucked from the shock fodder. In computing the value of the crops when produced, the average price of the crops in the shock has been used, as the cost of production is not carried further than that point.

The following table shows what may be considered an average day's work and gives a fixed cost per acre for the various field operations when a wage of \$2 per day for a man and \$1 per day for a horse is paid.

TABLE 5.—*Average day's work of man and team in tillage operations with cost per acre.*

Kind of work	No. of men	No. of horses	Average acres	Cost per acre
Plowing.....	1	4	3.5	\$1.75
Double disking.....	1	4	8	.75
Harrowing.....	1	4	35	.17
Drilling.....	1	4	15	.40
Cultivating.....	1	4	16	.38
Listing.....	1	4	8	.75 ¹
Harvesting { 1 man to shock.....			15	.13
Twine per acre.....				.25
Wear and repair on binder.....				.15

¹In Table 7 the cost price used for listing is 60 cents per acre, which is probably too low.

When winter rye and field peas have been used as a green-manure crop, the cost of seed has been estimated as \$1 per acre for rye and \$4 per acre for peas.

In the production of brome grass and alfalfa, the cost of seed per acre was \$1.40 and \$1.20, respectively. The cost of harvesting the crops was \$2 per acre.

By keeping an accurate record of the number of tillage operations performed in the production of the various crops, the values previously presented have enabled us to establish a fixed cost of production for each crop under any method of tillage. The data are shown in Table 6.

TABLE 6.—Costs and values used in computing profit or loss in Table 7.

Crop	Cost of producing crops, in dollars per acre							Value of crop in the shock	
	F. plowed	S. plowed	Disked	Listed	Greenmanure		Fallowed	Grain per bushel	Forage ¹ per ton
					Rye	Peas			
Corn.....	\$7.49	\$7.11	.....	\$5.98	.....	.....	\$12.36	\$0.40	\$3.00
S. wheat.....	6.56	6.09	\$4.75	5.55	\$13.11	\$16.11	11.50	.70	.80
Oats.....	6.31	5.84	4.50	5.30	12.85	15.86	11.25	.30	1.00
Barley.....	6.46	5.99	4.65	5.45	13.01	16.01	11.40	.41	.40
Sorghum.....	7.44	7.06	.....	5.93	.....	.....	12.31	.....	4.00
Note.	Manuring, per acre.....								\$4.00
	Plowing, per acre.....								1.71
	Disking, per acre.....								.75
	Harrowing, per acre.....								.17
	Drilling, per acre.....								.40
	Cultivating, per acre.....								.38
	Listing, per acre.....								.60
	Harvesting, per acre.....								.93

¹Forage is corn stover, straw, or sorghum hay.

The following table indicates the average annual profit or loss resulting from each plat and each rotation for the eight-year period as calculated when using the values indicated in the preceding tables. The results given in this table have been referred to so frequently thruout the preceding discussion that we deem it unnecessary to discuss them further.

TABLE 7.—Average annual production and profit or loss from different rotations, systems of cropping, and methods of tillage. Eight years, 1907-1914.

	Crop	Tillage	Av. yield per acre		Value of crop per acre	Cost of production per acre	Profit or loss per acre	Rotation		Rotation profit or loss	Profit or loss per acre
			Grain bu.	Forage lbs.				Value	Cost		
1	Oats.....	E. f. p. ¹	17.0	993	\$5.60	\$6.31	—\$0.71				
	Corn.....	E. f. p. ¹	13.6	2,153	8.67	7.49	1.18				
	S. wheat.....	Stu. disked ²	11.3	1,669	8.58	4.75	3.83	\$22.85	\$18.55	\$4.30	\$1.43
2	Oats.....	Sp. plowed ³	16.7	773	5.40	5.84	—44				
	Corn.....	Sp. plowed.....	13.7	2,068	8.58	7.11	1.47				
	S. wheat.....	Sp. plowed.....	10.2	1,353	7.68	6.09	1.59	21.66	19.04	2.62	.87
3	Oats.....	E. f. p. ¹	18.1	1,021	5.94	6.31	—37				
	Corn.....	E. f. p. ¹	15.3	2,166	9.37	7.49	1.88				
	S. wheat.....	F. p. ¹	12.8	1,644	9.62	6.56	3.06	24.93	20.36	4.57	1.52
4	S. wheat.....	E. f. p. ¹	9.3	1,454	7.09	6.56	.53				
	Corn.....	E. f. p. ¹	13.9	2,233	8.91	7.49	1.42				
	Oats.....	Stu. disked.....	17.9	797	5.77	4.50	1.27	21.77	18.55	3.22	1.07
5	Oats.....	E. f. p. ¹	16.3	814	5.30	6.31	—1.01				
	S. tillage.....	On s. t. ⁴				11.50	1.33				
	S. wheat.....	On s. t. ⁴	17.1	2,159	12.83			18.13	17.81	.32	.11

¹Early fall plowed.
²Stubble disked.

³Spring plowed.
⁴Summer tilled.

TABLE 7 continued.—Average annual production and profit or loss from different rotations, systems of cropping, and methods of tillage. Eight years, 1907-1914.

	Crop	Tillage	Av. yield per acre		Value of crop per acre	Cost of production per acre	Profit or loss per acre	Rotation		Rotation profit or loss	Profit or loss per acre
			Grain bu.	Forage lbs.				Value	Cost		
6	Oats.....	E. f. p.....	15.4	893	5.07	6.31	-1.24				
	Corn.....	E. f. p.....	13.5	2,206	8.71	7.49	1.22				
	Barley.....	Stu. disk'd....	13.4	817	5.65	4.65	1.00	19.43	18.45	0.98	0.33
7	Barley.....	Sp. plowed....	15.9	856	\$6.69	\$5.99	\$0.70				
	Corn.....	Sp. plowed....	14.5	2,400	9.40	7.11	2.29				
	Oats.....	Sp. plowed....	21.1	949	6.80	5.84	.96	\$22.89	\$18.94	\$3.95	\$1.32
8	S. wheat.....	E. f. p.....	12.7	180,9	9.61	6.56	3.05				
	S. tillage.....	On s. t.....	26.0	1,326	8.46	11.25	-2.79	18.07	17.81	.26	.09
9	S. wheat.....	Sp. plowed....	9.6	1,009	7.12	6.09	1.03				
	Corn.....	Sp. plowed....	13.8	2,411	9.14	7.11	2.03				
	Oats.....	Sp. plowed....	18.0	799	5.80	5.84	-.04	22.06	19.04	3.02	1.01
14	Corn.....	Sp. plowed....	12.6	2,050	8.12	7.11	1.01				
	S. wheat.....	Stu. disk'd....	10.3	1,395	7.77	4.75	3.02				
	Rye.....	F. plowed....									
	Oats.....	On g. m ^a	19.1	970	6.22	12.85	-6.63	22.11	24.71	-2.60	-.65

^aGreen manure.

TABLE 7 continued.—Average annual production and profit or loss from different rotations, systems of cropping, and methods of tillage. Eight years, 1907-1914.

	Crop	Tillage	Av. yield per acre		Value of crop per acre	Cost of production per acre	Profit or loss per acre	Rotation		Rotation profit or loss	Profit or loss per acre
			Grain bu.	Forage lbs.				Value	Cost		
16	Corn.....	Sp. plowed....	15.5	2,493	9.94	7.11	2.83				
	S. wheat....	Stu. disked....	11.6	1,554	8.74	4.75	3.99				
	Peas.....	F. plowed....									
	Oats.....	On g. m.....	23.2	1,271	7.60	15.86	-8.26	26.28	27.72	-1.44	-0.36
19	Corn.....	Sp. plowed....	12.3	1,950	7.85	7.11	.74				
	S. wheat....	Stu. disked....	11.0	1,534	8.31	4.75	3.56				
	S. tillage....										
	Oats.....	On s. t.....	24.7	1,223	8.02	11.25	-3.23	24.18	23.11	1.07	.27
41	Corn.....	Sp. plowed....	10.7	2,286	7.71	7.11	.60				
	S. wheat....	Stu. disked....	10.2	1,284	7.65	4.75	2.90				
	Brome grass..	F. plowed....				8.54					
	Brome grass..	Meadow.....				3.60					
42	Brome grass..	Meadow.....		609	1.52	3.60	-14.22				
	Oats.....	F. plowed....	12.0	783	3.99	6.31	-2.32	20.87	33.81	-12.94	-2.16
	Corn.....	Sp. plowed....	10.5	2,359	\$7.74	\$7.11	\$0.63				
	S. wheat....	Stu. disked....	8.6	1,301	6.54	4.75	1.79				
42	Alfalfa.....	F. plowed....				8.34					
	Alfalfa.....	Meadow.....				3.60					
	Alfalfa.....	Meadow.....		894	2.68	3.60	-12.86				
	Oats.....	F. plowed....	12.2	706	4.01	6.31	-2.30	\$20.97	\$33.71	-\$12.74	-\$2.12

TABLE 7 continued.—Average annual production and profit or loss from different rotations, systems of cropping, and methods of tillage. Eight years, 1907-1914.

	Crop	Tillage	Av. yield per acre		Value of crop per acre	Cost of production per acre	Profit or loss per acre	Rotation		Rotation profit or loss	Profit or loss per acre
			Grain bu.	Forage lbs.				Value	Cost		
43	Oats.....	Manure.....	19.2	1,004	6.26	10.31	— 4.05				
	Corn.....	F. plowed.....	13.1	2,169	8.49	7.49	1.00				
	S. wheat.....	E. f. p.....	11.1	1,586	8.40	6.56	1.84	23.15	24.36	—1.21	—0.40
44	Sorghum.....	Manure.....		5,856	11.71	11.06	0.65				
	Corn.....	S. plowed.....	10.1	2,079	7.16	7.49	—0.33				
	S. wheat.....	F. plowed.....	9.9	1,477	7.52	4.75	2.77	26.39	23.30	3.09	1.03
45	Oats.....	On g. m.....	20.2	1,099	6.61	12.85	—6.24				
	Corn.....	F. plowed.....	11.0	2,003	7.40	7.49	—0.09				
	Rye.....	Stu. disked.....						14.01	20.34	—6.33	—2.11
46	Oats.....	On g. m.....	21.0	990	6.80	15.86	—9.06				
	Corn.....	E. f. p.....	13.7	2,354	9.01	7.49	1.52				
	Peas.....	F. plowed.....						15.81	23.35	—7.54	—2.51
47	Oats.....	Sp. plowed.....	8.1	787	2.82	5.84	—3.02				
	Corn.....	E. f. p.....	13.9	2,240	8.92	7.49	1.43				
	Sorghum.....	Manure.....		6,464	12.93	11.06	1.87	24.67	24.39	0.28	0.09

TABLE 7 continued.—Average annual production and profit or loss from different rotations, systems of cropping, and methods of tillage. Eight years, 1907-1914.

	Crop	Tillage	Av. yield per acre		Value of crop per acre	Cost of production per acre	Profit or loss per acre	Rotation		Rotation profit or loss	Profit or loss per acre
			Grain bu.	Forage lbs.				Value	Cost		
48	Oats.....	Sp. plowed....	10.1	1,040	\$3.53	\$5.84	—\$2.31				
	Sorghum.....	Sp. plowed....	.....	6,316	12.63	7.06	5.57				
	Sp. wheat.....	Sp. plowed....	9.7	1,195	7.27	6.09	1.18	\$23.43	\$18.99	\$4.44	\$1.48
49	Sp. wheat.....	Str. disked....	9.8	1,248	7.36	4.75	2.61				
	Corn.....	F. plowed....	9.9	1,411	6.08	7.49	—1.41	13.44	12.24	1.20	0.60
50	Oats.....	On s. t.....	32.6	1,380	10.47	11.25	—0.78				
	Corn.....	Sp. plowed....	14.8	2,749	10.04	7.11	2.93				
MC C or	S. tillage.....							20.51	18.36	2.15	0.72
	A Corn.....	Sp. plowed....	18.5	2,438	11.06	7.11	3.95	11.06	7.11	3.95	3.95
	B Corn.....	F. plowed....	18.2	2,363	10.85	7.49	3.36	10.85	7.49	3.36	3.36
MC C or	D Corn.....	On s. t.....	20.8	2,711	12.39	12.36	0.03	12.39	12.36	0.03	0.03
	A Sp. wheat.....	Sp. plowed....	12.2	1,520	9.15	6.09	3.06	9.15	6.09	3.06	3.06
	B Sp. wheat.....	F. plowed....	11.7	1,624	8.84	6.56	2.28	8.84	6.56	2.28	2.28
MC C or	D Sp. wheat.....	On s. t.....	18.0	.....	13.61	11.50	2.11	13.61	11.50	2.11	2.11
	A Oats.....	Sp. plowed....	16.5	787	5.28	5.84	—0.56	5.52	5.84	—0.56	—0.56
	B Oats.....	F. plowed....	20.7	1,170	6.80	6.31	0.49	6.80	6.31	0.49	0.49
MC C or	D Oats.....	On s. t.....	27.5	1,417	8.96	11.25	—2.29	8.96	11.25	—2.29	—2.29

TABLE 7 continued.—Average annual production and profit or loss from different rotations, systems of cropping, and methods of tillage. Eight years, 1907-1914.

	Crop	Tillage	Av. yield per acre		Value of crop per acre	Cost of production per acre	Profit or loss per acre	Rotation		Rotation profit or loss	Profit or loss per acre
			Grain bu.	Forage lbs.				Value	Cost		
MC C or	A Barley	Sp. plowed	15.8	821	6.64	5.99	0.65	6.64	5.99	0.65	0.65
	B Barley	F. plowed	17.1	1,120	7.23	6.46	0.77	7.23	6.46	0.77	0.77
	D Barley	On s. t.	26.7	1,871	9.32	11.40	-2.08	9.32	11.40	-2.08	-2.08

See Table 6 for values used in making these computations.

TABLE 8.—*Eight years' average yield of spring wheat, oats, barley, corn, and sorghum from different methods of seed-bed preparation and crop sequence. Bushels of grain and pounds of forage per acre, 1907-1914.*

Preparation of seed bed	Previous crop	Spring wheat	Oats	Barley	Corn		Sorghum forage
					Grain	Stover	
Fall plowed . .	Sp. wheat . . .	11.7	17.1	.....	11.9	2,019	
	Oats	11.1	20.7	.....	13.4	2,184	
	Barley . . . . .	.....	15.4	17.1	.....	.....	
	Corn	12.0	.....	.....	18.2	2,383	
	Sp. wheat. } ¹ Manure. . }	.....	19.2	.....	.....	.....	
	Alfalfa . . . . .	.....	12.2	.....	.....	.....	
	Brome grass . . . . .	.....	12.0	.....	.....	.....	
Spring plowed	Sp. wheat . . .	12.2	19.4	.....	13.8	2,411	
	Oats	9.6	16.3	15.9	13.8	2,262	6,316
	Barley . . . . .	.....	.....	15.8	14.5	2,400	
	Corn	10.2	19.6	.....	18.5	2,438	
	Sorghum	10.1	16.5	.....	.....	.....	
	Sp. wheat. } ¹ Manure. . }	.....	.....	.....	.....	.....	5,857
	Corn . . . . .	.....	.....	.....	.....	.....	6,464
	¹ Manure. . } Oats . . . . . }	.....	.....	.....	10.6	2,323	
Green manure	Rye . . . . .	.....	21.7	.....	.....	.....	
	Peas . . . . .	.....	22.2	.....	.....	.....	
Disked	Corn	10.4	17.9	13.4	.....	.....	
Summer tilled . . . .	.....	16.8	27.4	26.7	20.8	2,711	

¹ Manure applied to stubble of previous crop before plowing.

² In sod rotations.

TABLE 9¹.—*Yield of spring wheat in bushels per acre as influenced by different methods of seed-bed preparation and the previous crop, with profit or loss per acre.*

	Effect of tillage				Effect of previous crop		
	Fall plowed	Spring plowed	Disked	Summer tilled	After corn	After small grain	After sorghum
Number plats	5	4	8	3	11	5	1
	Bu. av.	Bu. av.	Bu. av.	Bu. av.	Bu. av.	Bu. av.	Bu. av.
1907.....	24.7	23.1	24.5	28.9	24.1	24.8	23.5
1908.....	27.8	21.1	24.2	41.4	25.0	24.4	20.3
1909.....	18.0	18.3	14.5	22.6	16.0	17.4	16.3
1910.....	7.1	7.4	7.3	15.3	7.1	7.2	8.7
1911.....	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1912.....	6.7	7.7	4.6	7.1	5.0	8.4	5.8
1913.....	2.5	2.2	3.0	6.8	3.0	1.7	3.3
1914.....	5.7	4.6	5.1	12.5	5.2	5.1	5.2
Average per acre	11.6	10.6	10.4	16.8	10.7	11.1	10.1

CROP VALUE, COST, AND PROFIT, OR LOSS IN DOLLARS PER ACRE.

Average							
² Value of crop.	\$8.12	\$7.42	\$7.28	\$11.76	.....	.....	.....
Cost of production.....	6.56	6.09	4.75	11.50	.....	.....	.....
Profit or loss.....	1.56	1.33	2.53	.26	.....	.....	.....

¹ Straw is not given any value in this table.² See Table 6 for values used in making these computations.

TABLE 11¹.—Yield of oats in bushels per acre as influenced by different methods of seed-bed preparation and the previous crop, with profit or loss per acre.

No. plats	Effect of tillage					Effect of previous crop			
	Fall plowed	Spring plowed	Disked	Green manure	Summer tilled	Sod	After corn	After small grain	After sorghum
	6	6	1	4	4	2	3	9	1
<i>Year</i>	<i>Bu. av.</i>	<i>Bu. av.</i>	<i>Bu. av.</i>	<i>Bu. av.</i>	<i>Bu. av.</i>	<i>Bu. av.</i>	<i>Bu. av.</i>	<i>Bu. av.</i>	<i>Bu. av.</i>
1907.....	30.5	33.0	40.6	29.5	34.3	23.1	36.6	31.3	30.0
1908.....	60.2	47.2	53.4	74.8	87.1	38.4	54.0	54.6	45.0
1909.....	23.6	31.4	22.5	34.0	37.3	15.5	28.3	26.5	28.8
1910.....	7.9	11.5	11.9	15.5	26.2	3.6	12.1	9.3	8.1
1911.....	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1912.....	10.7	16.2	6.6	12.0	19.6	9.9	11.8	13.3	12.5
1913.....	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1914.....	9.4	8.4	7.8	9.9	14.9	6.4	9.1	8.8	7.8
Average per acre.....	17.8	18.5	17.9	22.0	27.4	19.0	19.0	18.0	16.5

CROP VALUE, COST, AND PROFIT OR LOSS IN DOLLARS PER ACRE.

Average				
² Value of crop.....	\$5.34	\$5.55	\$5.37	\$6.60
Cost of production.....	6.31	5.84	4.50	14.36
Profit or loss.....	— .97	— .29	.87	— 7.76
				\$8.22
				11.25
				— 3.03

¹Straw is not given any value in this table.²See Table 6 for values used in making these computations.

TABLE 12¹.—*Yield of barley in bushels per acre as influenced by different methods of seed-bed preparation and the previous crop, with profit or loss per acre.*

	Effect of tillage				Effect of previous crop	
	Fall plowed	Spring plowed	Disked	Summer tilled	After small grain	After corn
No. plats	1	2	1	1	3	1
Year	Bu. av.	Bu. av.	Bu. av.	Bu. av.	Bu. av.	Bu. av.
1907.....	40.0	39.6	30.6	39.0	39.7	30.6
1908.....	43.3	21.0	24.9	67.7	28.4	24.9
1909.....	10.4	20.1	21.5	23.8	16.8	21.5
1910.....	12.5	14.9	7.9	26.0	14.1	7.9
1911.....	0.0	0.0	0.0	0.0	0.0	0.0
1912.....	14.6	20.4	12.3	10.0	18.5	12.3
1913.....	5.0	6.4	5.0	16.5	5.9	5.0
1914.....	11.0	4.5	5.2	20.8	6.6	5.2
Average per acre.	17.1	15.9	13.4	26.7	16.3	13.4

CROP VALUE, COST, AND PROFIT OR LOSS IN DOLLARS PER ACRE.

Average						
Value of crop...	\$7.01	\$6.52	\$5.49	\$10.95	.....	.....
Cost of production	6.46	5.99	4.65	11.40	.....	.....
Profit or loss....	.55	.53	.84	— .45	.....	.....

¹ Straw is not given any value in this table.

² See Table 6 for values used in making these computations.

TABLE 13.—Record of precipitation by months, for 40 years, at North Platte, Nebraska, as reported by the United States Weather Bureau.

Year	Jan.	Feb.	March	April	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Total	Departure from normal
1875	24	26	40	6.21	1.69	1.62	2.12	.66	1.40	.14	.52	.09	15.35	-3.15
1876	.09	.13	.49	.51	2.97	.49	1.16	2.46	1.47	1.07	.49	.51	11.84	-6.66
1877	1.38	.37	.19	1.15	3.22	2.99	2.04	5.03	4.49	1.23	.30	3.86	25.47	+6.97
1878	1.77	.00	1.40	1.16	3.24	3.86	2.58	1.52	.91	.13	.46	2.20	18.62	+ .12
1879	2.33	.43	.11	1.92	2.25	3.31	8.47	.16	1.40	.21	1.0	.37	20.06	+1.56
1880	.03	.03	.18	.16	2.28	3.12	2.87	3.96	1.53	2.72	.23	.37	17.48	-1.02
1881	.16	.76	1.26	.87	4.84	6.12	3.09	.75	2.36	2.22	.37	.13	22.98	+4.43
1882	.46	.13	.04	1.94	3.98	4.84	2.66	1.68	1.28	1.23	.01	.71	17.95	— .55
1883	1.20	1.38	.47	3.02	4.07	7.49	1.34	4.51	1.08	3.47	.42	1.43	29.88	+11.38
1884	.10	.23	1.56	2.14	2.40	1.39	2.19	2.13	.08	.74	.04	.27	13.67	+4.98
1885	.12	.16	.37	1.69	3.31	3.79	3.12	4.37	1.86	1.18	1.71	.96	22.03	+3.58
1886	.09	.17	.63	2.09	3.67	1.14	.88	1.99	1.22	.69	.43	.40	13.10	-6.40
1887	.13	.49	.42	3.41	.81	3.20	3.05	4.51	5.10	.15	.19	.30	21.68	+3.13
1888	.06	.49	1.22	2.36	4.93	2.76	2.31	.53	5.55	1.12	.08	.42	17.46	-1.04
1889	.07	.42	1.43	2.66	2.91	1.86	6.01	2.95	2.70	.31	.20	.64	20.56	+2.16
1890	.35	.39	.32	2.56	1.20	2.06	3.37	2.42	3.97	.54	.42	.03	12.71	-5.19
1891	.85	.49	2.19	2.86	1.79	7.13	3.53	2.31	5.55	1.50	.08	.69	23.36	+4.95
1892	1.04	.97	1.51	2.56	3.70	3.39	3.33	3.32	3.92	1.65	.11	.40	20.37	+1.37
1893	.03	.62	1.33	1.15	1.35	4.11	3.33	3.37	1.43	.55	.11	.73	13.16	-5.33
1894	.33	.29	1.72	1.63	1.35	3.54	2.39	2.13	.43	.09	.04	T.	11.53	-7.33
1895	.14	.84	.09	1.93	2.38	3.35	1.98	2.13	1.43	.09	.36	.11	14.52	-8.32
1896	.27	.06	.37	3.43	1.47	2.76	1.96	2.07	1.84	1.51	.36	.21	16.52	-1.36
1897	.47	.46	.56	2.59	1.11	1.72	1.85	3.05	5.59	4.11	.36	.53	17.02	-1.11
1898	.77	.19	.64	1.42	4.12	2.54	1.99	1.40	2.56	.07	.55	.10	15.54	-2.66
1899	.11	.36	.83	.82	3.58	1.98	2.04	1.33	2.28	.28	1.59	.32	13.99	-2.51
1900	.06	.78	.26	3.34	1.93	1.43	3.37	1.37	2.35	.39	.09	.06	12.29	-6.31
1901	.04	.44	1.53	2.53	1.83	3.69	3.34	2.00	3.14	.41	.30	.16	14.44	-2.06
1902	.40	.35	1.42	.92	7.98	3.48	3.34	1.74	3.34	1.32	.78	.27	23.27	+7.77
1903	.27	1.29	.95	1.32	3.74	3.98	4.56	1.74	8.34	1.32	.44	.28	13.86	-1.14
1904	.32	.69	.25	1.52	3.63	3.43	2.93	3.53	7.76	1.44	.03	.19	23.17	+4.67
1905	.90	.69	.62	3.78	4.56	7.63	4.30	3.25	1.23	1.05	.67	.19	26.81	+8.31
1906	.61	.80	2.22	2.89	2.82	6.28	3.14	5.56	4.25	8.05	1.01	.96	27.99	+9.49
1907	.39	.51	.10	.43	2.40	2.69	6.79	2.14	2.91	.14	.31	.80	19.61	+1.11
1908	.16	.78	.98	.64	3.95	5.07	3.17	1.57	24	3.39	.59	.20	19.96	+1.46
1909	.29	1.61	.98	.72	2.32	5.46	5.21	1.24	.77	.20	2.24	1.37	22.41	+3.91
1910	.34	.02	.19	.48	2.59	2.75	.50	2.02	.97	.01	.11	.72	10.70	-7.30
1911	.28	.39	.20	2.48	1.78	1.18	3.31	2.11	1.37	3.86	.04	.65	17.43	-1.07
1912	.74	.81	8.03	2.93	1.93	.57	4.01	1.37	2.04	1.12	.01	.13	18.69	+ .19
1913	.16	.94	1.68	2.07	3.50	2.13	3.37	.98	.90	1.14	.14	.30	19.10	+ .60
1914	.18	.96	.41	1.48	2.14	4.68	.58	3.45	.17	.92	T.	.87	15.79	+2.71
Averages	.41	.50	.35	2.02	2.80	3.26	2.83	2.32	1.43	1.11	.40	.58	18.50	.....

*T. indicates Trace; less than one-hundredth of an inch.

FROST FREE PERIOD **NORTH PLATTE, NEBRASKA** **1875-1914, INC.**

APRIL MAY JUNE JULY AUGUST SEPT. OCT.

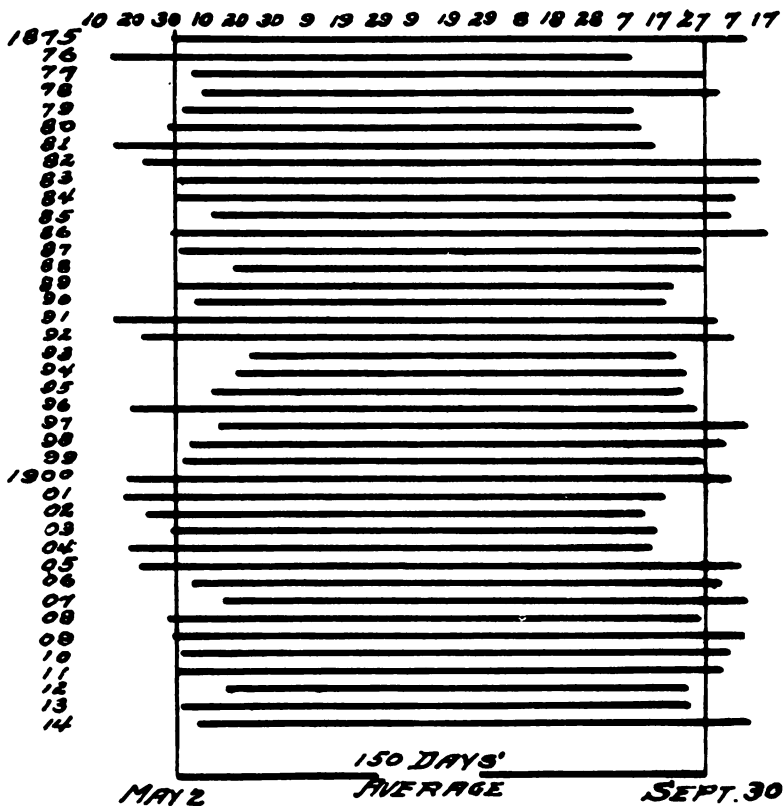


Chart V.

SEASONAL EVAPORATION
AND PRECIPITATION
NORTH PLATTE, NEBR.

A. SHOWS AVERAGE AMOUNT OF
EVAPORATION AND PRECIPITATION
FOR SMALL-GRAIN SEASON.

B. SHOWS THE SAME THING FOR
THE CORN-GROWING SEASON.

C. NO. 1 TOTAL OF CHART A.
NO. 2 TOTAL OF CHART B.

D. SHOWS AVERAGE AMOUNT OF
PRECIPITATION AND EVAPORATION
FROM APRIL 1 TO AUG. 31.

E. SHOWS AVERAGE ANNUAL
PRECIPITATION AND AVERAGE AMOUNT
OF EVAPORATION. APRIL 1-SEPT. 30

N.B.- DATA COMPUTED FROM RECORDS
FROM 1907 TO 1914 INCLUSIVE.

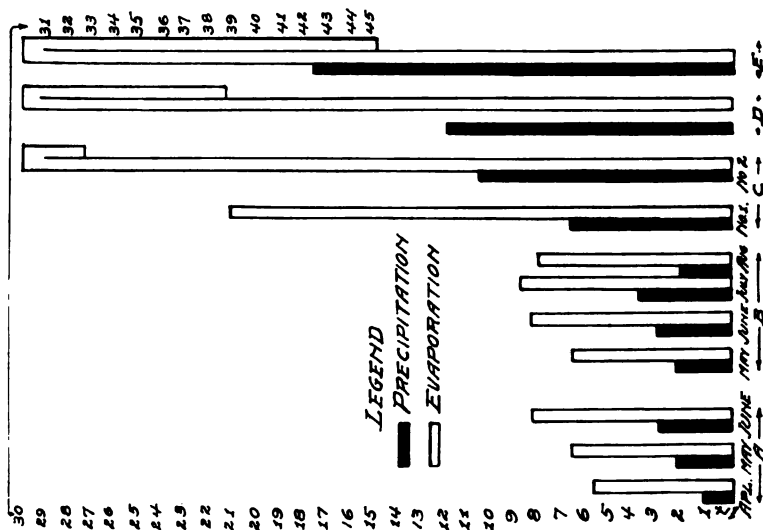


Chart VI.

(12-23-'15-8 M.)

Five

BULLETIN NO. 155.
(POPULAR EDITION.)
NORTH PLATTE SUBSTATION BULLETIN No. 17.)

THE UNIVERSITY OF NEBRASKA.

BULLETIN

OF THE

AGRICULTURAL EXPERIMENT STATION

OF

NEBRASKA.

VOLUME XXVIII, ARTICLE III.

ROTATIONS AND TILLAGE METHODS IN
WESTERN NEBRASKA.

REPORT OF EXPERIMENTAL SUBSTATION, NORTH PLATTE, NEBRASKA.

BY W. P. SNYDER AND W. M. OSBORN.

W. P. SNYDER, Superintendent.
E. A. BURNETT, Director.

DISTRIBUTED SEPTEMBER 25, 1915.



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LINCOLN, NEBRASKA
U. S. A.

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¹Resigned.

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SUMMARY.

The results of eight years of careful experimentation thruout a series of favorable and a series of unfavorable years indicate that the common methods of growing crops in this region—the result of 30 years' experimentation and observation by intelligent farmers—are founded on sound principles of economic production. Moisture conditions are so all-powerful in controlling yields that tillage methods, rotations, crop sequences, and soil fertility are all thrown into the background. The changes in weather conditions from season to season and from day to day of each season are so radical and so various that one system of tillage may succeed one year and another system succeed the next year. However, there are a few rather broad principles that apply to a wide range of conditions covering the medium and also many of the extreme conditions. All of these principles are subject to modification, as there are no set and fast rules. It has been rather clearly established that moisture is the chief factor controlling crop production in this region. There seems to be an excess of fertility over available moisture at the present time. Therefore, any expense incurred for the purpose of maintaining or increasing the fertility is largely a loss so far as the yields of the succeeding crops indicate.

Moisture is largely lost thru vegetation rather than from the surface of the soil. The soil mulch assists in retaining moisture under certain conditions but does not always retain sufficient moisture to pay the cost of maintaining an ideal mulch. Summer tilling the land retains a part of the rainfall and gives some security against drouth, but the cost of summer tilling has not been fully paid by increased yields of corn or spring grain. While the soil and crops respond to thoro methods of tillage, they do not respond sufficiently to extreme methods of tillage to pay for the added expense.

A system of tillage that does not permit the soil to be robbed of moisture by vegetation which has no market value, and that keeps the surface of the soil from becoming hard and smooth, seems to accomplish the practical ends of tillage. While more labor than is required to accomplish these ends may increase the yields, yet the increase is likely not to be sufficient to return as much for a unit of labor expended in the extreme tillage as in the less intensive and more practical tillage.

While on high-priced land a large part of the cost of production comes as land rental, this charge is relatively less on land of low value, and the labor involved becomes the largest factor in

the cost of production. This labor cost has a greater influence in the cost of producing a bushel of grain than the method of production. The results of this work indicate that the less expensive practices give the greater net profit. Small grain following corn has given more net profit than small grain following small grain, not because the former practice gave the greater yields but because the labor cost of the latter practice was less than of the former. Summer tillage and green-manure crops have increased the yield of the crops but not the profits because of the increased cost per acre. One of the chief ways of increasing profits is by reducing operating expenses. The factors entering into the cost of production aforementioned make practices of tillage commendable on low-priced land that should not be recommended on high-priced land. Profit in crop production in this region is likely to come from farming a large acreage with the minimum man labor and an adequate supply of power.

"Good farming" is to be recommended in this region as strongly as in the more humid sections, but this term does not necessarily mean identical or even similar practices under the two distinctly different sets of conditions.

Yield per acre usually is taken as the measure of profitable production. A low yield means a small profit or a loss and a high yield means a large profit. But this is not necessarily true. Europe produces high yields per acre but small profits per man. The measure of good farming in America is profit per man rather than yield per acre. As the yield per acre is increased beyond a certain normal, the cost per bushel, on the average, will be increased, tho in individual cases or during short periods of time the reverse may be true.

While the results in crop production herein reported represent losses during severe years, like figures for almost any business enterprise would show similar results during periods of depression. Also, if we could include with this report the results the farmer obtained by keeping live stock and feeding the roughage grown during these years to the stock, the final item of profit would look much more favorable. This report deals only with certain phases of the farmer's operations, and these phases are those most noticeably affected by unfavorable seasons. That the farmer did not get fair wages for growing a certain crop, by a certain method, during a certain year, is not sufficient basis for asserting that the farmer did or did not make money during that year. It is probable that the farmer who judiciously combined live stock farming with grain production secured a profit during the most unfavorable season.

ROTATIONS AND TILLAGE METHODS IN WESTERN NEBRASKA.

BY W. P. SNYDER AND W. M. OSBORN.¹

INTRODUCTION.

In the spring of 1906 a series of one-tenth acre plats was laid out on the table-land of the North Platte Experimental Substation. In these plats there are being tried various rotations, crop sequences, and methods of tillage in the production of corn, spring wheat, oats, barley, and sorghum hay. There are 92 plats in this series. Each plat is 2 rods by 8 rods in extent. The plats are grouped so as to indicate the relative effects of plowing and disking, of fall plowing and spring plowing, of growing one kind of crop continuously year after year on the same land and rotating the crops each season, of continuous cropping and alternate or occasional summer tillage, the effects of barnyard manure, green manure, or no manure, and of other common farm practices.

There is always an opportunity to check the result on a certain plat by the result on another plat where the only difference in the previous treatment of the two plats is the factor under consideration. Therefore, a result may be traced to its cause with a fair degree of accuracy. Fall and spring plowing may be cited as an example. By referring to Chart I it will be noted that Rotations 2 and 3 are similar excepting that in Rotation 2, the soil is always spring plowed, while in Rotation 3, the soil is always fall plowed. As Plat A of each of these rotations is seeded on the same day with the same drill and in the same manner, and as all other operations on these two plats except the time of

¹Assistant in Soils and Crops, Experimental Substation, North Platte, and Assistant Agriculturist, Office of Dry Land Agriculture, Bureau of Plant Industry, United States Department of Agriculture. Mr. Osborn resigned March 1, 1915, and was succeeded by Mr. L. L. Zook.

The data presented in this bulletin relating to climatic conditions and soil moisture have been obtained by the North Platte Substation in cooperation with the Biophysical Laboratory and Office of Dry Land Agriculture, Bureau of Plant Industry, United States Department of Agriculture.

The data from which this report is compiled were gathered in the years 1906 to 1912 inclusive by Mr. W. W. Burr, then Associate in Soils and Crops, North Platte Experimental Substation, and Assistant Agriculturist in Dry Land Agriculture, United States Department of Agriculture, who was transferred in March, 1913, to become Assistant in the Office of Dry Land Agriculture, United States Department of Agriculture. The data for 1913 and 1914 were gathered by Mr. W. M. Osborn, as above indicated.

plowing are similar, it is reasonable to presume that the difference in yield is due to this one factor in which the tillage methods differ, namely, the time of plowing.

The yield of any one year may be influenced greatly by a local seasonal condition unusually favorable to the one or the other time of plowing, but when the results of eight seasons are combined, it would seem we have a fair basis for determining the probable relative results of fall and spring plowing. The basis of comparison is further strengthened by averaging the results of several fall-plowed plats and an equal number of spring-plowed plats.

A plat only 2 rods by 8 rods appears too small for practical results to the man whose fields are from 40 acres to a half section in area. But it should be remembered that these plats are each handled as distinctly separate from each other as are large fields and that each plat has the same conditions as each other plat. It may be true that hot winds affect fields of small area more than those of large area, but we have noted that the yield on these plats has been about the same as that on larger fields tilled in like manner. The use of plats of this size has been carefully considered by experimenters not only thruout the United States but also in Europe, and the consensus of opinion is in favor of the small plat with checks.

Crops grown according to a definite method of tillage differ greatly in yields from year to year. Also there is considerable variation of yields each season on plats tilled in different ways. But the variations from time to time are not all in the same direction, and as yet it is not possible to foretell what method of seed-bed preparation will give the larger yield or larger net profit at the succeeding harvest. It is fairly well established that, on the average, certain methods will give better results than certain other methods, but during any season under trial the results may be the opposite of the average result.

Some plats have been plowed each season for corn and the corn planted with the lister. We do not advocate this as the best farm practice for this region, but it is used in this work in order to keep all factors affecting the various plats as uniform as possible and still consistent with the objects sought.

When this work was planned, winter wheat was purposely omitted, but at a later time a similar series of plats was laid out in which winter wheat formed the basis of the rotations. As this later work has not been in progress as long, it is not considered in this report, altho winter wheat is a more profitable crop than any of the spring grains.

NORTH PLATTE, NEBRASKA

FIELD 41

S.P. SPRING PLOWING
F.P. FALL PLOWING
D.D. DISKED IN PREPARATION
FOR SEEDING

A OATS	B OATS F.P.	C OATS	D OATS	E OATS	F OATS F.P.	G OATS	H OATS F.P.	I OATS	J OATS F.P.	K OATS	L OATS F.P.	M OATS	N OATS F.P.	O OATS	P OATS F.P.	Q OATS	R OATS F.P.	S OATS	T OATS F.P.	U OATS	V OATS F.P.	W OATS	X OATS F.P.	Y OATS	Z OATS F.P.
A CORN F.P.	B CORN F.P.	C CORN F.P.	D CORN F.P.	E CORN F.P.	F CORN F.P.	G CORN F.P.	H CORN F.P.	I CORN F.P.	J CORN F.P.	K CORN F.P.	L CORN F.P.	M CORN F.P.	N CORN F.P.	O CORN F.P.	P CORN F.P.	Q CORN F.P.	R CORN F.P.	S CORN F.P.	T CORN F.P.	U CORN F.P.	V CORN F.P.	W CORN F.P.	X CORN F.P.	Y CORN F.P.	Z CORN F.P.
A RYE	B RYE	C RYE	D RYE	E RYE	F RYE	G RYE	H RYE	I RYE	J RYE	K RYE	L RYE	M RYE	N RYE	O RYE	P RYE	Q RYE	R RYE	S RYE	T RYE	U RYE	V RYE	W RYE	X RYE	Y RYE	Z RYE
A CORN S.P.	B CORN S.P.	C CORN S.P.	D CORN S.P.	E CORN S.P.	F CORN S.P.	G CORN S.P.	H CORN S.P.	I CORN S.P.	J CORN S.P.	K CORN S.P.	L CORN S.P.	M CORN S.P.	N CORN S.P.	O CORN S.P.	P CORN S.P.	Q CORN S.P.	R CORN S.P.	S CORN S.P.	T CORN S.P.	U CORN S.P.	V CORN S.P.	W CORN S.P.	X CORN S.P.	Y CORN S.P.	Z CORN S.P.
A WHEAT D.	B WHEAT D.	C WHEAT D.	D WHEAT D.	E WHEAT D.	F WHEAT D.	G WHEAT D.	H WHEAT D.	I WHEAT D.	J WHEAT D.	K WHEAT D.	L WHEAT D.	M WHEAT D.	N WHEAT D.	O WHEAT D.	P WHEAT D.	Q WHEAT D.	R WHEAT D.	S WHEAT D.	T WHEAT D.	U WHEAT D.	V WHEAT D.	W WHEAT D.	X WHEAT D.	Y WHEAT D.	Z WHEAT D.
A FALLOW	B FALLOW	C FALLOW	D FALLOW	E FALLOW	F FALLOW	G FALLOW	H FALLOW	I FALLOW	J FALLOW	K FALLOW	L FALLOW	M FALLOW	N FALLOW	O FALLOW	P FALLOW	Q FALLOW	R FALLOW	S FALLOW	T FALLOW	U FALLOW	V FALLOW	W FALLOW	X FALLOW	Y FALLOW	Z FALLOW

WEATHER CONDITIONS.

The weather conditions of the eight years since these tests began have not favored profitable crops every year. In fact, for the small-grain crops there were three favorable and five unfavorable seasons and for corn four good and four poor seasons. The total rainfall of these years might lead one to expect fewer seasons of unprofitable returns, as the average precipitation of these eight years is 17.96 inches. This is only 0.54 inch below the average annual precipitation of a period of 40 years. The distribution of the rainfall thruout the season is fully as effective as the amount. The year 1912 may be cited as an example. The total precipitation was slightly above the normal. The rainfall in March was heavy, being 2.23 inches above the normal of 0.85 inch. April followed with 2.93 inches. This was 0.92 inch above the normal. The rainfall of May was 1.93 inches or 0.87 inch below the normal, but the three spring months, March, April, and May, gave 2.28 inches above the normal. This would seem to give some assurance of a large small-grain crop. June followed—hot, windy, and dry. The normal rainfall for June is 3.26 inches, but in June, 1912, there was only 0.57 inch of rainfall. This was the critical time for the small-grain crops. As a result of unfavorable weather conditions in June, the yields of small grain were very low. However, July gave a rainfall of 4.01 inches, or 1.18 inches above the normal. Tho the August rainfall was only about half the normal, there was more than the normal amount in September, and a good corn crop was harvested. The amount of precipitation, the distribution of the precipitation, and the occurrence of precipitation at times when the crop needs it, as well as temperature, wind velocity, and humidity of the atmosphere—three factors which largely control the moisture demands of the crop—all play important parts in the crop growth and yield. All these factors must work in harmony for maximum crop yields.

WEATHER RATHER THAN TILLAGE CONTROLS YIELD.

The weather conditions of the season during which the crop is grown is the greatest factor controlling yields. The seasonal precipitation has a much greater influence on crop production than methods of seed-bed preparation, crop sequence, or manure.

The average yield of corn on all plats in 1908, 1909, and 1912 was 26.2, 26.4, and 26 bushels per acre. These were seasons when the weather conditions were favorable for producing corn. Only 3 plats out of 22 yielded less than 20 bushels per acre in 1908. The lowest yielding plat in 1909 gave 21.6 bushels per

TABLE 1.—Record of precipitation by months, for 40 years, at North Platte, Nebraska, as reported by the United States Weather Bureau.

Year	Jan.	Feb.	March	April	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Total	Departure from normal
1875	.24	.26	.40	6.21	1.69	1.62	2.12	.66	1.40	.14	.52	.09	15.35	-3.15
1876	.09	.13	.49	.51	2.97	.49	1.16	2.46	1.47	1.07	.49	.51	11.84	-6.66
1877	.38	.37	.19	.37	3.22	2.99	2.04	5.03	4.49	1.23	.30	.36	25.47	+6.97
1878	.00	.18	1.40	1.15	3.24	5.85	3.58	1.52	.91	.13	.46	.20	18.62	+1.12
1879	.23	.43	.11	1.92	2.25	3.31	8.47	.16	1.40	.21	.10	.37	20.06	+1.56
1880	.03	.03	.18	1.16	2.28	3.12	2.87	3.96	1.53	2.72	.23	.37	17.48	+1.02
1881	.16	.76	1.26	.87	4.84	6.12	3.09	1.68	2.36	2.22	.37	.13	22.93	+4.43
1882	.46	.13	.04	1.94	3.98	4.84	2.65	1.68	2.96	1.28	.01	.17	17.95	-.55
1883	1.20	1.38	.04	1.94	4.07	7.49	1.34	4.51	1.08	8.47	.42	.27	29.88	+11.38
1884	.10	.23	1.86	2.14	2.40	1.39	2.19	2.13	.86	.74	.04	.40	13.57	-4.93
1885	.12	.16	.37	1.59	3.31	3.79	3.12	4.87	1.22	1.18	.17	.95	22.03	+3.53
1886	.09	.17	.63	2.09	3.67	1.14	.68	1.99	1.22	.69	.43	.40	13.10	-.54
1887	.15	.49	.22	3.41	.81	3.20	3.05	4.61	5.10	1.15	.19	.30	21.68	+3.18
1888	.09	.42	1.44	2.36	4.93	2.76	2.61	.65	.58	1.12	.08	.42	17.46	-1.04
1889	.35	.33	.27	2.65	2.71	1.95	6.01	2.06	2.57	.31	.20	.54	20.66	+2.16
1890	.65	.49	.62	4.46	.90	2.06	.39	2.45	.86	.84	.42	.03	12.71	+4.86
1891	.104	.97	2.19	2.58	1.69	7.19	3.91	3.01	.57	.57	.08	.69	23.36	+1.87
1892	.03	.62	1.29	1.15	3.70	.60	1.13	3.62	.32	.05	.11	.40	13.16	-5.34
1893	.33	.29	1.72	1.64	1.35	4.11	1.13	.17	.14	.59	.01	T. ¹	11.21	-7.29
1894	.14	.84	.09	1.93	2.38	3.54	1.08	2.13	.48	.09	.96	.11	14.58	-3.92
1895	.27	.06	.37	3.44	1.47	2.76	1.86	2.07	1.84	1.51	.16	.21	16.52	-1.98
1896	.47	.46	.66	2.59	.11	1.72	1.85	3.05	.59	4.11	.85	.63	17.09	-1.41
1897	.77	.19	.64	1.42	4.12	2.54	1.29	1.40	2.56	.07	.51	.08	15.54	-2.96
1898	.11	.36	.83	.82	3.68	1.95	2.04	1.83	.28	.28	1.59	.32	13.99	-4.51
1899	.06	.78	.26	3.34	.90	1.42	3.37	1.37	.25	.39	.09	.06	12.29	-4.51
1900	.04	.44	1.53	2.53	1.83	.34	2.04	1.37	3.14	.41	.30	.19	16.44	-2.06
1901	.27	.35	1.42	.92	7.98	3.46	4.56	1.74	3.34	1.32	T. ¹	.78	26.27	+7.77
1902	.27	1.29	.12	.95	3.74	3.99	4.46	2.00	3.14	.44	.28	.01	18.86	-.14
1903	.32	.06	.52	1.52	3.63	3.99	2.93	3.58	.76	.44	.28	.01	23.17	-4.67
1904	.90	.69	2.15	3.78	4.56	7.63	4.90	3.25	2.40	1.92	.03	.19	26.81	+8.31
1905	.61	.80	2.22	2.89	4.56	7.63	2.58	1.57	1.23	1.05	.67	T. ¹	27.99	+9.49
1906	.39	.51	.10	.43	2.82	6.68	3.14	6.56	4.25	3.05	1.01	.31	19.61	+1.11
1907	.16	.78	.10	.64	2.40	2.69	6.79	2.14	2.91	.14	.31	.80	19.96	+1.46
1908	.29	1.61	.98	.72	2.32	5.07	3.17	1.57	2.24	3.39	.59	.20	22.41	+3.91
1909	.34	.02	.19	.48	2.59	2.76	5.21	1.24	.77	.01	.11	.72	10.70	-7.80
1910	.28	.39	.20	.48	2.48	1.73	3.31	2.11	.97	.30	.04	.65	17.43	-1.07
1911	.74	.81	3.08	2.93	1.93	1.57	4.01	2.11	1.37	3.66	.04	.65	18.69	+1.19
1912	.16	.94	1.68	2.07	3.50	2.13	3.37	1.27	2.04	1.12	.01	.18	17.63	-.80
1913	.16	.94	1.68	2.07	3.50	2.13	3.37	.98	1.14	.14	.14	.37	19.10	+1.19
1914	.18	.96	.41	1.48	2.14	4.63	.58	3.45	.17	.32	T. ¹	.87	15.79	-2.71
Averages	.41	.50	.85	2.02	2.80	3.26	2.83	2.32	1.43	1.11	.40	.58	18.50	.....

¹ T. indicates Trace; less than one-hundredth of an inch.

per acre. Three plats gave less than 20 bushels per acre in 1912. The seasons of 1911 and 1913 were so unfavorable for producing corn that corn was a failure under all methods of production. Only a few plats produced any grain, and the yield on these could not be credited to any one system of production.

Similar results are shown by the yields of small grain. The seasons of 1907 and 1908 were favorable for producing small grain. There was an average yield of 24.7 bushels per acre of spring wheat on all plats during the former year and 26.3 bushels per acre during the latter year. No plat yielded as low as 20 bushels per acre in 1907, and only two plats fell below this amount in 1908. There were 19 plats in spring wheat. In 1911, spring wheat was a failure. From 1910 to 1914 inclusive no plat yielded as much as 20 bushels per acre. The variation of the eight-year average yield of the various plats is about 200 per cent, while the variation of the yields on each plat from year to year is many hundred per cent, on one plat being a variation from zero to 42.

During favorable seasons, profitable crops have been produced by all methods, and during unfavorable seasons profitable crops have not been produced by any method.

SUMMER TILLAGE VS. CONTINUOUS CROPPING.

The system of alternate cropping and summer tillage has failed to overcome severe drouth conditions and has been less profitable in the production of corn and spring grain than ordinary methods of production. However, this system, during some unfavorable years, has given a large increase in yields over common practices and thus has served as a partial insurance against entire crop failure.

As has been stated, under extremely unfavorable conditions no method of production has given yields of grain. In 1908 summer-tilled land produced 38.2 bushels of corn per acre but during the same season a plat of corn following corn produced 38.6 bushels per acre and the average yield of 22 plats of corn was 26.2 bushels per acre. In 1909 corn on summer-tilled land yielded 25 bushels per acre, but 16 plats out of the remaining 21 yielded 25 or more bushels per acre and the average yield of the 22 plats was 26.4 bushels per acre. In 1912, the third good corn year, summer-tilled land gave 35.1 bushels per acre, but a plat of corn following corn gave 39.9 bushels per acre and the average yield of all plats was 26 bushels per acre. In 1911 grain was not produced on any corn plat, and the yield of fodder was not as large on the summer-tilled plat as on certain other plats. Almost no grain was produced in 1913. The yield of fodder this season

on the summer-tilled plat was higher than on any other plat and about one and one-half times higher than the average of all plats. In 1907 the summer-tilled plat gave 17.9 bushels per acre. Of the 21 other plats, 15 yielded more than the summer-tilled plat and 5 yielded less. The average yield on all plats was 20.1 bushels per acre. In 1910 and 1914 the summer-tilled plat yielded much more than any other and several times the average of all the plats. During the former season the yield of the summer-tilled plat was 21.9 bushels per acre while the yield of all other plats was low, ranging from 1 to 15.4 bushels per acre with the average at 5.2 bushels. During 1914 the highest yield on a plat continuously cropped was 15.5 bushels, and the average yield of all plats was 5 bushels per acre, while the summer-tilled plat yielded 27.9 bushels per acre. The results of eight years, three of which were good corn years, one fair, two practically failures, and two complete failures, show an average yield of 20.8 bushels of corn from the summer-tilled plat, 18.2 for a plat that grew corn every year, and 13.6 bushels for all plats. It should be remembered that the yield of the summer-tilled plat is a biennial rather than an annual yield; that this yield must always be divided by two in order to get the annual yield. The results of these eight years indicate that if an acre of land had been growing corn under ordinary methods of tillage it would have yielded in the eight years 106 bushels of corn and 9 tons of fodder, or if it had been summer tilled one year and cropped the next it would have yielded in the eight years 83 bushels of corn and 5.4 tons of fodder.

The yields of spring wheat throw more light on the problem of summer tillage. In 1907, a good wheat year, of two summer-tilled plats growing spring wheat, one produced 31.8 bushels per acre and the other 26 bushels per acre. Two plats not fallowed produced 28.3 and 28.7 bushels per acre. The average yield of all plats was 24.7 bushels per acre. In 1908 one of the summer-tilled plats yielded 40.5 bushels per acre and the other 42.2 bushels per acre. The highest yield on any other plat was 31.3 bushels per acre. The average of all plats was 26.3 bushels per acre. The lowest yield of any plat was 17.5 bushels per acre. In 1909, one summer-tilled plat yielded at the rate of 18 bushels per acre and the other at the rate of 27.2 bushels per acre. The highest yield on any plat not summer-tilled was 24.3 bushels per acre and the lowest yield was 8.1 bushels per acre. The average yield of the 19 plats was 17.1 bushels per acre. In 1911, wheat was a failure on all plats. From 1910 to 1914 the yields were very low. In 1910, one summer-tilled plat yielded 18.3 bushels per acre and the other 14.3 bushels per acre. The average yield

of these plats was twice the average yield of the 19 plats. Each summer-tilled plat yielded more than any plat not summer tilled. In 1912 one summer-tilled plat yielded 10.5 bushels per acre and the other 9.2. Of two plats that had grown wheat continuously, one yielded 12.8 bushels per acre and the other 11.2 bushels per acre. The average yield of all plats was 6.4 bushels per acre. In 1913, one of the summer-tilled plats yielded 10 and the other 7.3 bushels per acre. The average yield of these two was more than twice the average yield of all plats. The highest yield on any plat not summer tilled was 4.3 bushels per acre. In 1914, one summer-tilled plat yielded 15.2 and the other 10.4 bushels per acre. The average yield of all plats was 6.3 bushels per acre and the highest of any plat not summer tilled was 8.8 bushels per acre. The average yield for eight years of one summer-tilled plat is 18 and of the other summer-tilled plat 17 bushels per acre. The average yield of all plats was 11.5 bushels per acre. Of two plats continuously cropped to wheat, one yielded 12.9 bushels and the other 12.2 bushels per acre. The lowest eight-year average of any plat was 8.6 bushels per acre. As with corn, the yield of the summer-tilled plat must be divided by two in order to get the annual yield. These results indicate that during these eight years if an acre had been cropped continuously it would have yielded 87.2¹ bushels of spring wheat, while if the acre had been summer tilled and cropped alternately it would have yielded 68 bushels of spring wheat.

Oats have responded to the various methods of tillage in about the same manner as spring wheat. The average yield in 1908 was 61.8 bushels per acre. The maximum yield was 91.5 bushels per acre on a summer-tilled plat. Another summer-tilled plat yielded 91 bushels per acre. In 1911 and 1913, oats were a failure on all plats. The eight-year average gives an average yield of 27.4 bushels of oats per acre on the four summer-tilled plats. This is approximately 10 bushels per acre more than from plats that grew a crop each year. According to these results, an acre cropped continuously for eight years would have yielded 142 bushels of oats, while an acre summer tilled one year and cropped the next would have yielded 109 bushels of oats in eight years.

The yields of barley on summer-tilled land favor this method more than the yields from other spring grains or corn. In 1907, barley on summer-tilled land did not yield quite as much as on some land not summer tilled but more than the average of the land cropped each year. The average of all plats was 37.8

¹The average of spring- and fall-plowed and disked corn land, which was 10.9 bushels per acre. From Table 1, Limited Edition.

bushels per acre. In 1908 the summer-tilled plat seeded to barley yielded 67.7 bushels per acre, while the highest yield from any plat continuously cropped was 43.3 bushels per acre. Barley on the summer-tilled plat in 1909 yielded 23.8 bushels per acre, which was about 2 bushels per acre more than land that had grown corn the year previous. In 1910 the summer-tilled plat yielded 26 bushels per acre, while the highest yield on a plat continuously cropped was 16 bushels per acre. The 1911 crop was a failure on all the plats. In 1912 the summer-tilled plat gave 20 bushels per acre, which was slightly less than two plats continuously cropped and only slightly above the average of all plats. In 1913 and 1914 the summer-tilled plat yielded from two to four times as much as the plats continuously cropped. The eight-year average yield of the four plats continuously cropped was 15.5 bushels per acre and of the summer-tilled plat 26.7 bushels per acre. Dividing the latter yield by two give an annual yield of 13.3 bushels per acre from a plat summer tilled. In eight years, an acre of land continuously cropped, according to these results, would have yielded 124 bushels of barley, while an acre alternately cropped and summer tilled would have yielded 106.8 bushels of barley.

When we consider the average yearly profit¹ or loss per acre for the eight years, we find that corn grown on summer-tilled land gave a loss of 3 cents as against a profit of \$3.65 where corn was grown continuously. Spring wheat gave a profit of \$2.11 when grown on summer-tilled land as against a profit of \$2.28 or \$3.06 on land that grew wheat continuously. Oats gave a loss of \$2.29 per acre on summer-tilled land, while on land continuously cropped the loss was small. Barley gave a loss of \$2.08 per acre on summer-tilled land, while it gave a small profit on land continuously cropped.

SPRING PLOWING VS. FALL PLOWING.

We recognize that there is but little land plowed for spring small grain or corn. Land is usually prepared for corn by disking and listing. Spring small grain is usually sown on cornstalk land prepared by disking. These practices are commendable, but occasionally it is advisable to plow in preparing the seed-bed. The results of these eight-years' tests indicate that from the standpoint of yields or profit it matters but little whether the land is spring plowed or fall plowed for corn or spring grains.

¹For manner of arriving at cost of production, see the Limited Edition of this bulletin which will be sent on request.

The average yield of corn on the spring-plowed plats and on the fall-plowed plats planted to corn was almost the same for each of the eight years excepting 1910, a very poor corn year, when the spring-plowed plats gave an average yield of 6.1 bushels and the fall-plowed plats an average yield of 2.8 bushels per acre. The average yield for the eight years was 13.1 bushels per acre for the fall-plowed plats and 13.6 bushels per acre for the spring-plowed plats. In the production of spring wheat, during no season were the results from fall plowing much different from the results of spring plowing excepting in 1908 when fall plowing gave an average yield of about 6 bushels per acre more than spring plowing. The average of the eight years gives a margin of 1 bushel per acre yearly in favor of fall plowing. In the yields of oats, there is more variation from year to year. The final eight-year average gives a margin of about 1 bushel per acre yearly in favor of spring plowing. Barley reverses the results of oats in reference to the effect of spring and fall plowing. The cost of production indicates that spring plowing gives the greater profit per acre.

CORN STUBBLE VS. GRAIN STUBBLE FOR SMALL GRAIN.

The difference in the yield of spring wheat on land that grew spring grain or corn the previous year has not been marked during any season. The average of the eight years shows a margin of less than one-half bushel per acre yearly in favor of spring wheat following grain rather than following corn. Oats show practically the same results as spring wheat excepting that the eight-year average gives a margin of 1 bushel per acre yearly in favor of land that grew corn the previous year. Barley shows an annual average difference of 3 bushels per acre in favor of land that grew small grain the preceding year. A preceding crop of spring grain and a preceding crop of corn have had about the same effect on the yields of the spring grain crop following. But as corn stubble land is much more easily prepared for seeding to spring grain than small-grain stubble land, the land that previously grew corn shows the greater profit. In this work, corn stubble land usually has been double-disked twice and harrowed once while grain stubble land has been plowed once, double-disked once, and harrowed once in preparing it for seeding to small grain.

CORN OR SMALL GRAIN PRECEDING CORN.

During almost every year of the eight years under consideration, corn following corn has yielded more than corn following small grain. The average annual difference for the eight years

is 5 bushels per acre in favor of land that grew corn during the previous season. The fact that corn leaves the soil in condition for cheap production the following year is very much in favor of its cultivation.

EFFECT OF SORGHUM ON SUCCEEDING CROP.

Only two kinds of crops, spring wheat and oats, have been grown following sorghum sown for forage. The yields of these crops following sorghum have not been much different from the yields of the same crops following corn or spring grain. During most years, spring wheat has yielded more when following corn and spring grain than when following sorghum, but during some seasons the reverse has been true. The average for the eight years shows an annual yield of 0.6 bushel per acre more of spring wheat following corn and 1 bushel per acre more of spring wheat following small grain than of spring wheat following sorghum which had been sown broadcast for producing forage.

During no season did land that grew sorghum the previous year produce more oats than land that had grown corn or small grain the preceding year, but the annual yield from the sorghum land for the eight years was only 1.5 bushels per acre less than from the small-grain land and 2.5 bushels per acre less than from the corn land.

BARNYARD MANURE.

Barnyard manure has been applied to certain plats once in three years at the rate of about 10 tons per acre. In Rotation 43 of oats, corn, and spring wheat, all seeded on fall-plowed land, the manure was applied before plowing for oats. In Rotation 3 the same crops were grown in the same manner except that no manure was used. The value per acre annually of the crops from the rotation not having manure is \$1.78 more than the value of the crop from the rotation having manure.

The other rotations in which manure is used are 44 and 47, in both of which grain stubble is manured during the winter and spring plowed for sorghum. There is no rotation differing from either of these rotations in manure alone, but Rotation 48 is somewhat similar and may assist in ascertaining the value of manure. The eight-year average yield of sorghum hay from the plat in Rotation 44, where sorghum was grown on manured wheat stubble, was 5,856 pounds per acre yearly. In 47 the corresponding yield was 6,464 pounds, or the average of the two plats manured was 6,160 pounds. In Rotation 48, where sorghum followed oats and preceded wheat without any manure in the rotation, the average yearly yield for the eight years was 6,316

pounds. There is no indication that the barnyard manure increased the yield of sorghum forage.

Altho the manure has undoubtedly maintained or increased the fertility of the soil, it has given no appreciable beneficial effect on the yields of the succeeding crop. However, it should not be inferred that the application of barnyard manure is to be condemned. Generally the manure can be applied when there is little demand for the labor of men and teams. Also the cost of spreading manure on the land is not very different from the cost of dumping it into a ravine.

It is pretty definitely understood that water is the limiting factor in crop production in the Great Plains area. Organic matter if properly applied to the soil increases the efficiency of the water in the soil and tends to keep the soil in a good physical condition. Since the history of land longer farmed shows that the soil will eventually reach a point of diminishing returns unless plant food is returned to the soil thru the application of barnyard manure or some other form of fertilizer, it would seem advisable not to waste the barnyard manure even tho the succeeding yields as recorded in this bulletin do not show any beneficial effect from the use of the manure.

GREEN MANURE.

Both rye and field peas have been grown and plowed under when in blossom as green-manure crops. No practical difference has been noticed between the results from these two crops when used for this purpose. The use of green-manure crops has proved to be more expensive and less profitable than alternate cropping and summer tillage. Tho the yields have been increased by the green-manure crop, the additional cost of producing the crop, as represented by the rental of the land an extra year, the cost of the seed for the green-manure crop, and the extra tillage that must accompany this method, is so great that the final profit from this method of production is not as great as from ordinary methods.

ROTATIONS.

Nearly all rotations giving a loss were designed to maintain the soil fertility by barnyard manure, a green-manure crop, or a grass crop. The other final items of loss occurred where corn was grown on summer-tilled land, where oats were grown continuously on spring-plowed land or on summer-tilled land, or where barley was grown on summer-tilled land.

The rotations giving a net annual profit of less than \$1 per acre contained summer tillage as a regular practice once in three

years, except three rotations in each of which the ground was prepared for corn by plowing instead of by disking, which increased the cost about \$1 per acre, probably, without increasing the yields.

There was no rotation in which the crops were grown according to common farm practice conducted thoroly that did not give an average annual profit of more than \$1 per acre.

Corn grown continuously gave more profit than any rotation of crops except as noted in the following paragraph, and wheat grown continuously gave more profit than any rotation of crops or than any other crop grown continuously except corn, and also with the exception noted in the succeeding paragraph.

If we should assume that the barnyard manure did not materially increase the succeeding crop of sorghum, and we believe it did not, then the most profitable rotation of the entire series is sorghum, corn, and spring wheat. In this, corn stover is given a value of \$3 per ton and sorghum a value of \$4 per ton. The results place a relatively high value on sorghum where the forage may be used profitably at \$4 per ton.

Rotations of oats, corn, and spring wheat rank high in the profit per acre. The oats are usually the unprofitable crop in these rotations.

CROP SEQUENCE.

Continuous cropping of spring wheat has given an average yield practically as large as that obtained from corn land. Where spring wheat follows sorghum grown for forage, the average yield has not been greatly diminished when compared with spring wheat following corn or spring wheat. Where spring plowing is practiced, spring wheat following oats has given the lowest average yield of any crop sequence for wheat. This difference, however, has not resulted where the oats land was plowed in the fall. On fall-plowed land, continuous cropping of corn has averaged 4.9 bushels per acre more than following small grain, and on spring-plowed land a difference of 5.3 bushels per acre has favored the system of continuous cropping. Corn following sorghum has given the lowest average yield for eight years of any crop sequence for corn.

Oats following brome grass or alfalfa has been the lowest yielding sequence for oats for an average of eight years. On fall-plowed land, the highest average yielding sequence for oats has been continuous cropping of oats, and the lowest average yielding sequence of land annually cropped has been oats following barley. On spring-plowed land, oats following spring wheat and corn has given the highest average yields.

Barley grown on disked corn land has given the lowest average yield of any crop sequence for barley. Barley following oats has given practically as good results as continuous cropping of barley.

ALFALFA AND BROME GRASS.

Alfalfa and brome grass are each used three years in six-year rotations. The purpose of these rotations is the production of forage crops and the maintenance of soil fertility. During five years out of eight neither the alfalfa nor the brome grass has produced any forage. Since 1911, a permanent stand of neither has been secured. It is evident that neither of these forage crops has been used successfully in these rotations. The failure of these crops should be expected during all but unusually favorable seasons when grown on high table-land of this character unless seeded in rows and cultivated.

SORGHUM AS A FORAGE CROP.

Sorghum has been grown as a forage crop in certain rotations. It has been seeded with a press drill at the rate of 5 pecks per acre. The average yearly yield for seven years has been 3.1 tons per acre. During favorable seasons and also under drouth conditions sorghum has given a larger tonnage per acre than any other crop. The feeding value of sorghum, as reported in Bulletins 105 and 117 of this Station, is about the same as that of native hay.

RELATIVE VALUES OF CROPS GROWN.

As a single crop and also in rotations, corn ranks above any of the small-grain crops in the profit per acre where the stover and grain are both used. That corn leaves the soil in a condition which favors profit from the succeeding crop adds to its value. Spring wheat ranks next to corn and gives the most profit when it follows corn in a rotation. Barley has given less profit than spring wheat. Oats have usually been grown at a loss. When forage for live stock is given full consideration, sorghum ranks high. The yield of sorghum hay has averaged 3.1 tons per acre as against an average yield of corn following corn, which system has given the largest average of corn, of 18 bushels and 1½ tons of stover per acre. If corn is valued at 50 cents per bushel, corn stover at \$3 per ton, and sorghum hay at \$4 per ton, with the aforementioned yields, the corn would be slightly more valuable than the sorghum. But if the yield of corn following small grain were used with the prices given above, the corn crop would be worth

less per acre than the sorghum crop. Both of these crops have important places in a profitable system of farming on these table-lands.

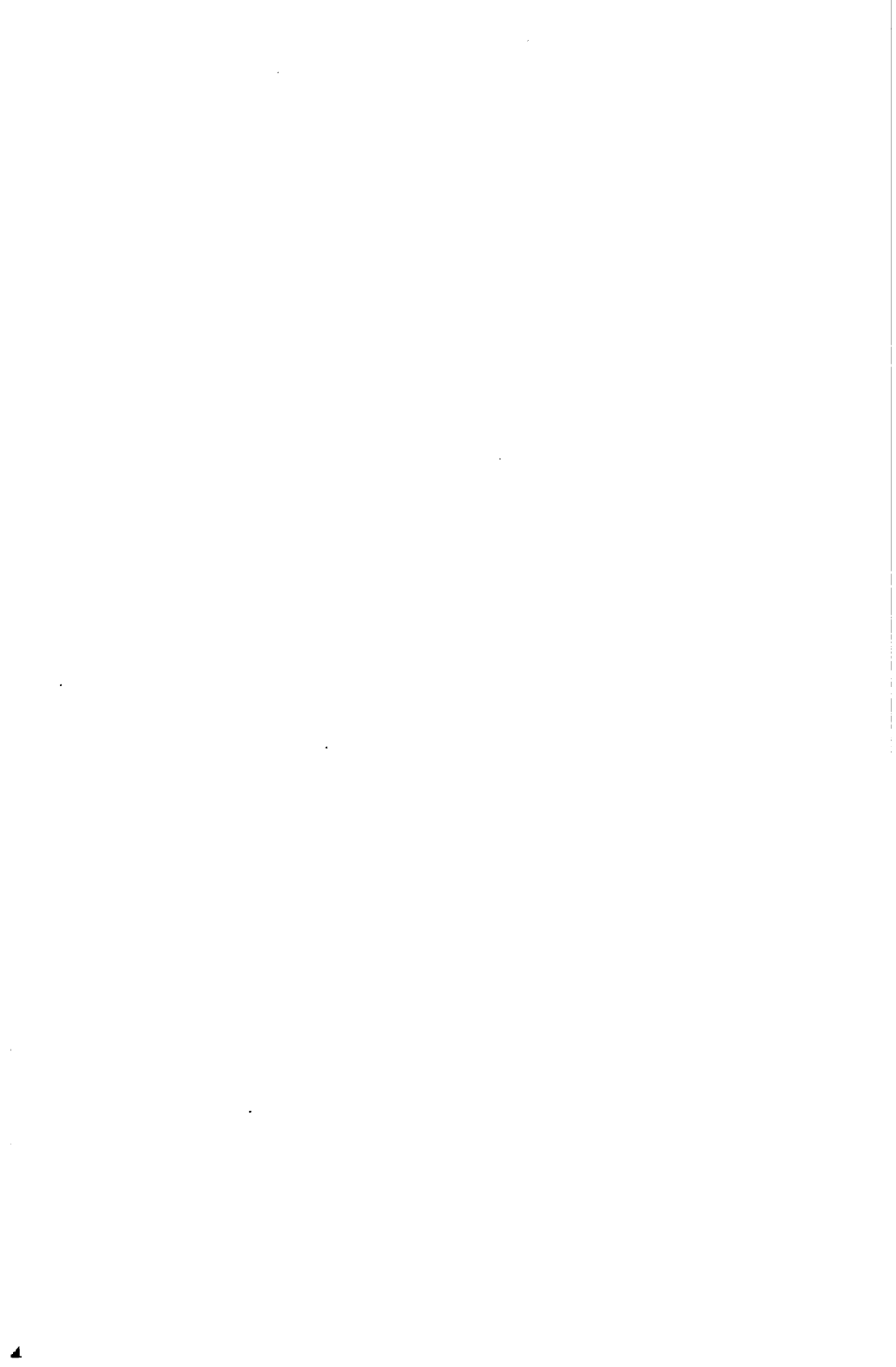
TABLE 2.—*Eight-years' average yield of spring wheat, oats, barley, corn, and sorghum from different methods of seed-bed preparation and crop sequences. Bushels of grain and pounds of forage per acre, 1907-1914.*

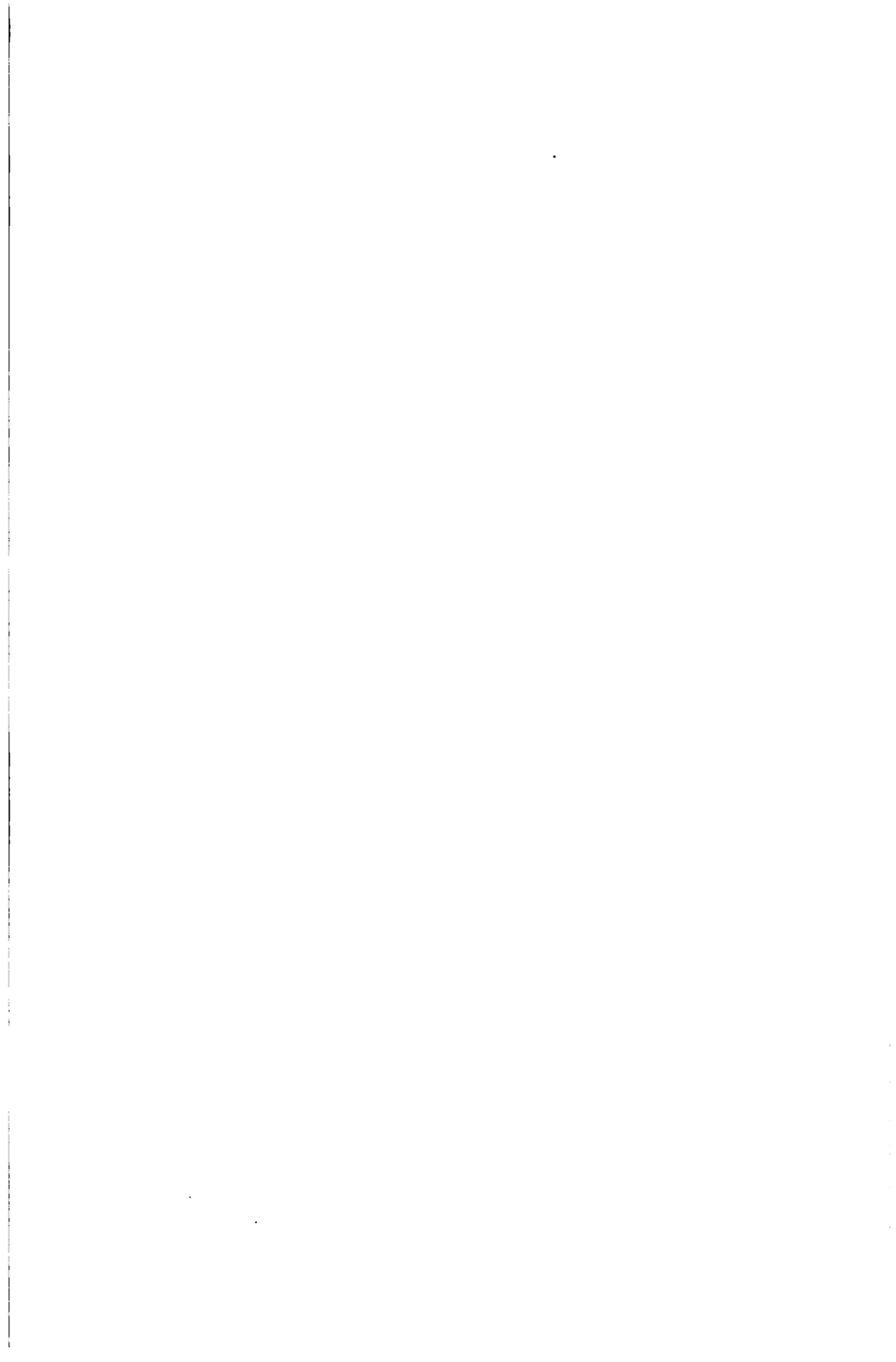
Preparation of seed bed	Previous crop	Spring wheat	Oats	Barley	Corn		Sorghum forage
					Grain	Stover	
		<i>Bus.</i>	<i>Bus.</i>	<i>Bus.</i>	<i>Bus.</i>	<i>Lbs.</i>	<i>Lbs.</i>
Fall plowed . . .	Sp. wheat	11.7	17.1	....	11.9	2,019	....
	Oats	11.1	20.7	....	13.4	2,184	....
	Barley . . . . .	....	15.4	17.1	....	....	....
	Corn	12.0	....	....	18.2	2,383	....
	Sp. wheat } Manure ¹ . . . . .	....	19.2	....	....	....	....
	Alfalfa . . . . .	....	12.2	....	....	....	....
	Brome grass . . . . .	....	12.0	....	....	....	....
Spring plowed . . .	Sp. wheat	12.2	19.4	....	13.8	2,411	....
	Oats	9.6	16.3	15.9	13.8	2,262	6,316
	Barley . . . . .	....	....	15.8	14.5	2,400	....
	Corn	10.2	19.6	....	18.5	2,438	....
	Sorghum	10.1	16.5	....	10.1	....	....
	Sp. wheat } Manure ² . . . . .	....	....	....	....	....	5,857
	Corn } Manure ² . . . . .	....	....	....	....	....	6,464
	Oats ¹ . . . . .	....	....	....	10.6	2,323	....
Green manure . . .	Rye . . . . .	....	21.7	....	....	....	....
	Peas . . . . .	....	22.2	....	....	....	....
Disked	Corn	10.4	17.9	13.4	....	....	....
Summer tilled . . .	....	16.8	27.4	26.7	20.8	2,711	....

¹In sod rotations.

²Manure applied to stubble of previous crop before plowing.

(9-10-'15-20M.)





17.2.2

BULLETIN NO. 156.
(VALENTINE SUBSTATION BULLETIN No. 1.)

THE UNIVERSITY OF NEBRASKA.
BULLETIN
OF THE
AGRICULTURAL EXPERIMENT STATION
OF
NEBRASKA.
VOLUME XXVIII, ARTICLE IV.

FARMING PRACTICE IN THE SAND HILLS
SECTION OF NEBRASKA.

REPORT OF EXPERIMENTAL SUBSTATION, VALENTINE, NEBRASKA.

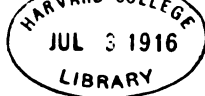
JAMES COWAN, Superintendent.
E. A. BURNETT, Director.

DISTRIBUTED MAY 25, 1916.



Concrete block barn at the Valentine Substation.

LINCOLN, NEBRASKA
U. S. A.



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¹Resigned.

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SUMMARY.

The Valentine Substation was established in 1910 for the purpose of aiding settlers and farmers in the Sand Hills district.

There are nearly 20,000 square miles of Sand Hills country in Nebraska, situated in the northwestern section of the State. Of the total area, there is not at the present time more than 200,000 acres that is not settled, and there are no whole sections of 640 acres open to homestead entry.

Generally speaking, the chief characteristics of the Sand Hills which affect farming are a light sandy soil, small precipitation, and extreme variations of temperature.

The Sand Hills country is primarily a cattle raising country, but the Kinkaid Act giving 640 acres for a homestead instead of 160 acres as under the old homestead act has attracted settlers in large numbers, and many of these are farming in favorable localities with considerable success.

The dry valley bottoms and the better portions of dune sand land are the principal farming lands of the Sand Hills country. Under cultivation, this land needs above everything else preservation of humus or organic matter, to enable it to retain moisture and to prevent the blowing of the soil.

No method of improving the range land in the Sand Hills country by the introduction of new grasses has been discovered, but the native herbage rapidly improves if it is not overgrazed and if fires are kept from running over it. The pasturage on the ranges is of good quality.

The hay for winter feeding, while not equal in nutritive quality to the range grasses, can be readily and cheaply improved by growing red and alsike clover among it; also winter forage can be greatly improved on the drier farming lands by growing alfalfa.

Work done at the Valentine Substation has proved that alfalfa can be grown in most sections of the Sand Hills country, and it is recommended that where possible it should be made to take the place of intertilled forage crops, because it would do away with the danger of soil blowing. It is also of more value than any other forage crop that can be grown. Experiments have shown that for this section of country alfalfa exceeds all clovers, including sweet clover, in its adaptability to the conditions found here, and that it is more valuable than any of them and costs less to seed.

Sweet clover has been found more adapted to hardpan lands than to Sand Hills lands.

Alsike and red clover, especially the former, are well adapted to wet valley meadow conditions, and when sown in with the native grasses are valuable for increasing the protein element in native hay.

Slender wheat, brome, and western wheat grasses are the only grasses that succeeded in making stands under dry soil conditions on cultivated ground at the Substation. None of them made much hay, and it is questionable if it is profitable to attempt grass growing on any but wet valley bottoms under the prevailing conditions of climate.

Sudan grass has yielded as high as 1,667 pounds of hay on light sandy soil when sown in rows 21 inches apart. Sown broadcast it yielded 1,649 pounds per acre. It is much relished by stock.

None of the other varieties of grain sorghums tested at the Substation equaled the upright headed dwarf milo in yield. The yield amounted to 11.2 bushels per acre on light soil in 1913, this being the highest recorded yield of three years' investigation.

Feterita is a good yielding grain sorghum and stands drouth well, but has not fully matured on the lighter upland soils. As a forage crop it is not relished by stock.

Corn yielded 13.6 bushels under conditions similar to those in which milo gave a yield of 11.2 bushels. At the Substation the variety known as Minnesota No. 13 gave heaviest yields. Corn in the Sand Hills has shown a very decided local character. Imported corn rarely does well until acclimated.

Of the so-called small grains, grown under conditions similar to grain sorghums and corn, the heaviest yields were obtained from winter rye, 11.80 bushels; emmer or spelts, 11.50 bushels; and winter wheat, 11.30. Along with the return given by the milo maize this shows a remarkable uniformity of yield in bushels per acre. All of these yields are strictly comparable with that of corn—13.60 bushels.

The Irish Cobbler potato has outyielded all other potatoes in tests covering three years.

The best depth to plant in light sandy soil is from 4 to 5 inches. The best yields were obtained with rows spaced 42 inches apart and 24 inches in the row. The most profitable size of sets was medium quartered.

Potatoes raised under ordinary conditions from seed that had been grown under a mulch yielded 13 bushels per acre more than when grown from seed that had been produced in the ordinary way.

Potatoes grown on light, sandy soil under a mulch of 6 inches of hay yielded 50 per cent more than when grown in the ordinary way.

Scab and stem rot are the only potato diseases of importance that have come under observation at the Substation. The formalin treatment has been applied with varying results. It is probably quite effective when the infection is confined to the seed alone, but the varying results obtained would seem to indicate that the disease is frequently communicated by the soil. In such a case, the only remedy would appear to be a rotation of crops.

For the Colorado beetle or potato bug, arsenate of lead has been found as effective as Paris green, and there is less risk of injuring the foliage of plants when using it.

Where a sufficient supply of manure is not available, or where owing to scarcity of moisture the ground is not capable of absorbing or assimilating sufficient manure, a rotation of crops is desirable in order to help to maintain the humus or organic matter in the soil. Alternating hoed crops with small grains helps. Many farmers practice a weed and corn rotation and claim success for this method.

The best quick-growing varieties of trees are Norway poplar, cottonwood, and box elder, but the first two species are short-lived.

Fast growing trees such as cottonwood, poplar, and box elder should not be mixed in with the slower growing varieties, but should be kept by themselves.

Of the slower growing, deciduous trees, the American elm and the honey locust have done best; to these may be added the Russian olive, which is, however, more of a lawn tree.

Among trees of the coniferous order, bull pines have done best. Jack pines kill back and grow straggly and do not seem to have the vitality of the bull pine.

Among other trees that have not done well are the ash, hardy catalpa, and red cedar.

Cultivation is most important, since weeds are the main enemies of the trees which succeed here. The spacing should be such as to permit cultivation, preferably with a disk. Care should be exercised when cultivating, especially with a shovel cultivator, that the shovels do not tear and break the roots owing to overdeep cultivation.

For tree culture in the Sand Hills country, clean cultivation and the preservation of an earth mulch is much more essential than watering.

When watering has to be done, it should be done thoroly, and more in the shape of a soak than a sprinkle. The quantity of water which it takes to soak the roots of a tree thoroly is not frequently realized.

Frequent light sprinkling is to be avoided, as it has a tendency to give the tree a shallow rooting habit.

For the same reason, mulching with straw should also be avoided.

Spiraea Van Houttei has made the best lawn shrub under Sand Hills conditions. Next to it is the buffalo berry. Tartarian honeysuckle has done well also. Tamarisk and lilac, tho but recently planted here, seem to do well.

Orchard trees, including apple, cherry, pear, and plum, do well in favorable situations, under conditions which include either irrigation or subirrigation, in the Sand Hills section.

Where orchard trees are unsheltered from prevailing winds, or where they have to depend on precipitation alone for moisture, they do not as a rule prove a success.

All varieties of small fruits grown in the Sand Hills are subject to practically the same limitations as orchard trees, and succeed or fail under practically the same conditions.

Vegetables grow splendidly in the Sand Hills, especially in the valleys and in sheltered places where they can be irrigated or where there is subirrigation.

Some varieties succeed on the drier uplands in light soil. Early planting is essential in this case.

Great care should be exercised in planting garden seeds, especially in dry light soil, that the ground after sowing be well compacted. For this purpose it is best to use the feet, as the degree of compactness can be easily gauged by the feel of the ground beneath them.

In laying down a lawn in the Sand Hills, it will frequently be found advisable to add sod to the surface soil. Well-rotted manure should also be liberally applied.

Seed for lawns should be sown early, using a nurse crop of some tender grass which will kill out when frost comes.

Top-dressing of lawns is of especial benefit in the Sand Hills, and old well-rotted manure should be used for the purpose.

It is not necessary to keep a blue-grass lawn green during the hottest weather, as it has been found that it will revive quickly, even if allowed to get quite brown.

In watering lawns the same principle as applies to trees is applicable. A lawn should be soaked, not sprinkled.

FARMING PRACTICE IN THE SAND HILLS SECTION OF NEBRASKA.

BY JAMES COWAN.

INTRODUCTION.

This bulletin is to cover the experimentation undertaken at the Valentine Substation during the past four or five years, and it is hoped, that farmers thruout the Sand Hills section, and more particularly the large number of new settlers, will find it helpful in solving at least some of the problems which confront them.

Increased confidence is felt that it will be serviceable in this way, because of the fact that the experiments were not chosen in a haphazard or arbitrary way, but were selected as subjects for investigation solely on the evidence of the interest shown in them.

During the year ending March 31, 1914, more than five hundred letters were received and answered at the Substation, a majority of which were seeking information on the subjects of farming practice discussed in this bulletin. Besides these, a large number were from persons residing in various parts of the United States, whose interest had been aroused by the recent land drawings.

Generally speaking, the larger Sand Hills problems so far as they relate to farming are: (1) The conservation of moisture and of organic matter or humus in the soil; (2) the prevention of soil erosion by blowing, which causes loss thru the removal of the surface soil as also thru the abrasion and covering of growing crops by the particles of sand and soil so shifted, or blown, as soil movement due to wind is locally termed; and (3) an increase in quantity and especially in quality of winter forage for stock.

THE DEMAND FOR WESTERN EXPERIMENT STATIONS.

Sometime previous to the year 1904 a demand had arisen in the western and mid-western sections of Nebraska for an Experimental Substation which might deal with the special agricultural or farming problems arising out of the climatic or other conditions peculiar to those parts of the country. It was in compliance with this demand that the North Platte Substation was established in that year.

The demand for this western Experimental Substation was emphasized chiefly because of the difference between eastern and western conditions of climate, particularly as regards moisture. The amount of precipitation grows gradually smaller as an advance is made in a westerly direction, until, as compared with that of the extreme eastern parts of the State, the precipitation on its western boundary is considerably less than half. As the only Experiment Station in Nebraska previous to the establishment of that at North Platte was at Lincoln, which is situated near the eastern boundary of the State, it was felt that experience obtained under the climatic conditions at the Station at Lincoln could not always be made the basis for recommendations applicable to farming in the western sections.

But the work done at North Platte relative to soil tillage and other operations connected with crop production has been carried out for the most part on what is known thruout the west as "hard" or table-land, which, with local modifications, does not differ greatly from much of the farming land found in the eastern and southern parts of the State, and is therefore without particular reference to soil conditions prevailing on farming land in that portion of the State known as the Sand Hills section of Nebraska.

GEOGRAPHY OF THE SAND HILLS COUNTRY.

The Sand Hills region of Nebraska stretches nearly three hundred miles, extending westward from about 98° west longitude. Its northern boundary is the Niobrara River, and its southern boundary the North Platte River. Its climatic conditions are similar to corresponding western parts of the State, but its soil, as stated, is essentially different from that of the "hard" land areas. The Sand Hills region covers an area of nearly 20,000 square miles, or about one-fourth of the area of the State of Nebraska. It contains many valleys of hard land, and many rich pasture districts, with smaller areas of meadow land interspersed.

PRIMARILY A CATTLE COUNTRY.

Until within rather recent years but little attention was given to the agricultural possibilities of this large section of the State, and it was devoted almost entirely to cattle raising, for which much of it is admirably adapted.

But the steady westward movement of settlers and homeseekers at length called attention to it as a possible area for settlement, and homeseekers began to settle in the most desirable

places, especially along the lake margins and in the river valleys, where were situated the natural hay flats or meadows. In this way many of the desirable locations were taken up prior to the passage of the Kinkaid Act.

THE KINKAID ACT OF 1904.

The most outstanding feature of the Kinkaid Act was the amending of the old Homestead law so as to permit the homesteader to file on 640 acres, and under its operation the most desirable locations in the region were soon taken up. Amendments of this Act coming into force on June 6, 1912, accelerated the settlement of most of the land remaining open at that date, until at the present time less than 200,000 acres remain open for settlement over the Sand Hills section, and no entire homesteads of 640 adjacent acres are now included in the available area.

VALENTINE SUBSTATION.

Just as a demand had arisen previous to the year 1904 for a Substation to deal with the hard land problems of western Nebraska, so again in the years immediately preceding 1910 the need for a Substation to handle the Sand Hills problems and assist the farmers and settlers of that section in their efforts to raise crops and establish homes began to make itself felt. Pressure thus brought to bear resulted in the passage of an Act by the Legislature of 1910 granting an appropriation of \$15,000 for the establishment of a Sand Hills Experimental Station under the direction of the Regents of the University of Nebraska. The land, amounting to about 1,984 acres of the old Fort Niobrara Military Reservation lying immediately east of the City of Valentine, the county seat of Cherry County, and between that place and the Niobrara River, was leased to the University of Nebraska by the Secretary of War, with the understanding that it could be retained so long as it should be used for experimental purposes. Subsequently the land comprising the Fort Niobrara Reservation passed from the control of the Secretary of War into that of the Department of the Interior, and most of it was thrown open for settlement in the year 1914. That occupied by the Substation at Valentine was reserved and tendered to the University at the nominal price of \$1.25 per acre, and has been purchased by the Board of Regents.

Subsequent to the action of the Secretary of War, an additional 40 acres lying between the west line of the Substation and the city of Valentine was deeded to the University by the people of Valentine to be used as the site of the buildings and permanent

improvements. This land has been found of great value for experimental work, as it is representative of the lighter and drier Sand Hills farming soil.

PRECIPITATION IN THE SAND HILLS SECTION.

Following is a table showing the precipitation by months since the Substation at Valentine was established. As the average precipitation for 25 years at Valentine is 22.46 inches, and the average given in the table only 17.93 inches, it will be seen that the work done here has been handicapped with an average yearly shortage of 4.53 inches of moisture.

TABLE 1.—*Record of precipitation by months for five years, at Valentine, Nebraska, as reported by the United States Weather Bureau.*

Year	January	February	March	April	May	June	July	August	September	October	November	December	Annual
1910.	1.61	0.27	0.86	0.12	1.16	5.12	2.14	4.95	0.67	0.20	0.12	1.22	18.44
1911....	0.40	0.71	0.48	2.34	1.37	0.99	0.68	3.60	2.17	4.81	0.05	0.30	17.90
1912....	0.49	0.34	1.26	2.43	3.06	0.99	2.07	2.60	1.48	1.07	0.01	0.24	15.99
1913....	0.15	0.44	1.19	2.94	3.13	1.03	3.94	2.54	1.15	0.19	0.45	0.88	18.03
1914....	0.07	0.56	0.47	3.53	1.59	3.94	1.43	2.50	2.65	1.79	0.08	0.68	19.29
1915....	0.57	1.35	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
Means.	0.54	0.61	0.85	2.27	2.06	2.41	2.05	3.24	1.61	1.61	0.14	0.66	17.93

DESCRIPTION OF SAND HILLS SOILS.

Exception is sometimes taken to the name of the Sand Hills section, but it is as descriptive of the general features of the country as any other could be. As will readily be understood from the name, sand of some description is the prominent if not the prevailing feature of the country. The various Sand Hills soils may be sufficiently classified for the present purpose under the names of dune sand or range land, wet valley land, and dry valley and bench lands.

DUNE SAND OR RANGE LAND.

Dune sand or range land comprises by far the greater portion of the total land area. This land, generally speaking, is more or less unfit for cultivation, altho it contains many level areas, which, with proper care, could be farmed profitably during years of average precipitation. As the land immediately surrounding the Substation is composed of this class of soil a number of the experiments given below refer to work done in connection with it.

Dune sand land has been classified as level to rolling, very rolling to hilly, hilly to very hilly, and broken. The greatest

obstacle to farming in this class of land, apart from the nature of the soil, is the scarcity of moisture. To a certain extent as a consequence of these, there is a tendency of this soil to blow or drift after it has been cultivated for a few years.



Fig. 1.—Blow-out in the Sand Hills.

It is this land that is used for summer pasture for the large herds of cattle that are found over the entire Sand Hills country. Used for this purpose the average capacity of this class of land would be about 32 head of cattle per section of land, or one head per 20 acres, while the average pasture season per year would be about seven months. The poorer portions of this class of land are almost pure sand from the surface downward, while in the better stretches the soil is a sandy loam, generally shading away to pure sand at a depth of from 30 inches to 3 feet. Generally speaking, this land is well covered with grasses which form a nutritive summer feed. The most conspicuous of these are little bluestem, Hall's beard grass, long-leaved reed grass, and western stipa. The Sand Hills pasture land is wonderfully rich in its variety of natural grasses.

WET VALLEY LAND.

In striking contrast to the range land just described is the much more limited tho fortunately quite extensive class of land known as wet valley land. It is on this land that the greater proportion of the winter feed for cattle—native hay—is produced.

This class of land is known geologically as Gannet fine sand, and is classified as a soil formed from wind laid deposits. Altho its name suggests sand, the soil itself is much more suggestive of muck and has been formed on this deposit by the decay of rank growing vegetation induced by the wet situation, for these wet valleys are the natural reservoirs of the surrounding country thru which they are distributed. Sometimes the reservoir takes the form of a shallow lake of dimensions which vary according to the seasonal or periodic rainfall. The surrounding hay meadows vary in size with the rise or fall of the lake. Others are all meadow at the drier seasons of the year, but often become shallow lakes during more moist seasons. In these valleys a few of the most valuable grasses are western wheat grass, slender wheat grass, big blue-stem grass, switch grass, wild timothy, and wild rye grasses. These valleys, while widely scattered over a vast area, are more numerous in the northern portion of the Sand Hills country. If a line be drawn straight south from Valentine for a distance of about forty miles, the main portion of the wet valley lands will be found to dot the country east and west of such a line. These valleys run for the most part in a general west-to-east direction. They are comparatively narrow, have abrupt hills rising on each side, but especially toward the north—which makes them ideal winter feeding grounds for stock. Being sheltered from northern winds, and with hay close at hand, stock can be winter fed at a minimum expense.

LITTLE FARMING ATTEMPTED IN WET VALLEYS.

Some farming has been done along the higher margins of such valleys. Corn has been raised, and alfalfa finds a congenial place when not too close to subsurface water. For the most part, however, these lands are covered with a rank growth of grass.

IMPROVING WET VALLEYS.

Within recent years systematic and efficient drainage has been carried out in a number of these valleys, draining the lakes and marshy spots and adding large tracts to the hay-producing lands of the region. When drainage is effected, the reclamation of the land is generally still further enhanced by seeding in timothy, alsike, and red clover, by scattering the seed over the surface. This sowing of leguminous seed is especially to be commended as a cheap method of supplying the nitrogenous or protein element which it is said is lacking in the native hay of the Sand Hills country. No sufficient data are at hand in regard to the value of such valleys for agricultural purposes. Surrounded by cattle ranges, they will probably always have their greatest

value as winter-feed producing lands for wintering live stock. It is probable that with enough drainage to lower the water level sufficiently beneath the surface they might be made to grow immense crops of clover and especially of alfalfa, which would be of greater value than native hay.

DRY VALLEY AND BENCH LAND.

The dry valley country is the third of the soil areas into which the Sand Hills country has here been divided. It is probably the most interesting from an agricultural standpoint, as it is certain that a greater variety of agricultural activities can be developed upon it than upon the other areas. It may be said to partake more of the nature of the hard lands than the others described. As indicating this, it is not uncommon to meet with stretches of buffalo and grama grass in these dry valleys in addition to many of the grasses mentioned above as common to the other divisions. These dry valley soils may be generally described as formed from water deposits, superimposed upon sand to a less extent than in the case of the "wet" valleys—which have a muck soil intermingled with wind blown sand. Geologically it is described as Valentine loamy sand. In general, these dry valleys have water underlying them, but the natural drainage is such that the water is retained at a sufficient depth below the surface to allow cultivated crops to be raised. Generally these valleys may be described as subirrigated, but they are not all so, and frequently their condition as regards moisture and moisture storage capacity resembles the better class of level or cupped dune sand land and valley bench land with which they are here classed. They are situated for the most part in the southern section of the Sand Hills country, the center of their area being probably somewhere in McPherson County.

Previous to the passage of the Kinkaid Act, Sand Hills homesteading was largely confined to the wet valley country, as the possession of hay land gave the key to the surrounding range land, which was at that time public domain. It was these earlier settlements that later became the nuclei of the large cattle ranches of the present day. When the rush of Kinkaid settlers began after 1904, it was found that a considerable amount of the wet valley lands, or hay meadows, was already deeded. The remainder was rapidly taken, and the later settlers frequently found themselves compelled to homestead in the dry valleys or on the better class of dune sand and bench lands, where sufficient native hay could not be cut for their own use. It therefore became necessary to raise winter feed by tillage. This was generally done by attempting to raise corn fodder and cane. Along with these the

homesteader grew vegetables, including potatoes, which grow well in the Sand Hills under favorable conditions. Frequently some small grains, such as oats, rye, and white spring emmer (spelts) for draft animals, and poultry, were grown. Thus, farming was gradually instituted in the Sand Hills country proper.

HUMUS THE GREAT NEED OF THE SAND HILLS SOILS.

For the first few years good crops were raised, if there was sufficient rainfall, and so long as the vegetable matter contained in the grass sod turned under with the first breaking lasted there was little or no trouble. But organic matter is quickly depleted in a hot sandy soil. The fibrous vegetable matter which gave the soil cohesion becoming used in part, and the ability of the soil to store moisture being thus lessened, it became more frequently dry than previously. The combination of dryness and looseness thus brought about by tillage of the soil combined with the action of high winds soon started that blowing or drifting of the upper soil which is one of the chief difficulties with which the Sand Hills farmer has to contend, and which, if unchecked, will, in the course of a few years, convert a fertile field into an immense sand pit.

OTHER CLIMATIC CONDITIONS OF THE SAND HILLS COUNTRY.

The question of moisture in the Sand Hills country has already been referred to and a table covering the last five years of precipitation given. Neither in this respect nor in any other referring to climate does the Sand Hills district greatly differ from corresponding longitudes in other parts of the State, except that, owing to its greater altitude and the more active radiation from the sandy soil, the nights are cooler, and the safe period for maturing such crops as corn and grain sorghums is correspondingly shorter.

THE SAND HILLS FARMER SHOULD BE A STOCK FARMER.

The Sand Hills farmer should be a stock farmer, for reasons so obvious that it is not necessary to discuss them within the limits of this bulletin. At present, the Substation at Valentine is engaged in trying to throw light on whether he can profitably be a dairy stock farmer, but as this work is only in its initial stage it will not be discussed here. In the meantime the chief problem is how to raise the most valuable kind of stock feed without deteriorating the land, which after all is only a Sand

Hills phase of the problem of how to make the farm pay without decreasing the stored up productivity of the soil, the accomplishment of which has been quoted as the chief end of good farming.



Fig. 2.—Native Sand Hills pasture.

THE SIZE OF THE FARM UNIT.

Nature has established a rough balance between the capacity of the Sand Hills range for summer feeding and the capacity of its winter-feed producing lands. Granted the homestead of 640 acres as the proper unit in Sand Hills farming, how much of this should be winter-feed producing land to enable the farmer to stay with his homestead? No attempt is made here to define how much land a farmer ought to have. The law has already fixed the number of acres which he can have under the Homestead Act as stated above. Probably 150 acres is a fair average for producing winter feed. Some contrive to get along with less, but a little more would be better.

Eighty acres of good hay-producing land would furnish him with all the winter feed for the cattle his pasture would carry; 100 acres would be ample for both them and his work animals. In good years he might have some hay to sell. An additional 60 acres would be ample for raising his cultivated crops, such as potatoes, corn, cane, rye, and spelts. This would permit the use of his manure and rotation to assist in keeping his soil from blowing. A good proportion between pasture and cultivated

land would be three-fourths pasture and one-fourth crop-producing land. Undoubtedly authorities would differ widely about this proportioning, but it may be accepted as near the average.

THE SUBSTATION SOIL IS TYPICAL OF THAT OF THE AVERAGE SAND HILLS HOMESTEAD.

About one-fourth of the land at the Substation is capable of cultivation and about three-fourths is suitable only for pasture. That is, out of the 1,124 acres which comprise the entire farm, considerably less than 300 acres is fitted for hay or other crop production. The range or pasture land represents every one of the classifications as applied previously to this kind of land. There is no land of the wet valley description, but both the sub-irrigated dry valley land and the dune sand land, or Valentine sandy loam soil without subirrigation, are well represented. On these, many experiments have been conducted with such crops as alfalfa, corn, cane, grasses, grain sorghums, garden truck, and trees, while methods of controlling blowing soil, the conservation of humus or organic matter, and moisture have been studied. Attention has also been given to the effect of various methods of handling manure on such land.

EQUIPMENT AT VALENTINE SUBSTATION.

When first placed at the disposal of the University Board of Regents, the land now comprising the Valentine Substation was open prairie land none of which had ever been fenced or broken. The pasture land was cut up by numerous wagon trails over which freight had been hauled to Fort Niobrara from the town of Valentine and vicinity. These trails and the unlimited grazing to which it had been subjected while lying as open range in the vicinity of a cattle-shipping point had rendered it bare in numerous spots where the sand had blown out and completely destroyed all vegetation. During the first year of occupation this land was fenced, and stock of all kinds was excluded. The larger blow-outs were covered over with stable litter and otherwise treated to prevent further drifting of the sandy soil. This treatment has resulted in a great improvement of this land, and it is a reasonable estimate that the amount of grazing available at the present time is 40 per cent greater than it was before the land came under Substation management.

In the spring of 1910 as soon as title had been acquired to the land donated for a site by the citizens of Valentine, plans for a number of cement block buildings were prepared. These consist of a modern, furnace heated, 8-room dwelling house with full basement; a horse barn 36 by 54 feet with hay storage above;

a dairy extension 35 by 62 feet; an implement shed 20 by 60 feet with storage above, and an engine room, boiler room, milk separating room, and workshop; a silo 16 by 32 feet; ice house, root cave, water tower, well, etc. As sand is one of the prevailing commodities of the country, it was determined to demonstrate its usefulness by making these buildings of cement blocks.



Fig. 3.—Concrete block residence at the Substation.

FIELD EXPERIMENT WORK.

If we consider only the natural feed resources of the Sand Hills country, it will be generally conceded that as between the nutritive quality of summer pasture and natural hay fed in winter, the winter feed is the more needful of improvement. This is largely because winter conditions are much more exacting than those of summer, but it is also quite probable that the coarser hay grown for the most part in muck soils is less nourishing in its natural state than the finer mixed grasses found on the ridges and uplands.

IMPROVING SAND HILLS PASTURE.

So far as is known, nothing has been found so well adapted to the sandy pasture areas of the Sand Hills country as the native grasses. The amount of pasture produced on any given area where

these grasses grow is in direct proportion to the amount of seasonal moisture available. This is because sandy ridges and the lighter class of dune sand land do not conserve moisture.

This being so, the hope of improving Sand Hills pasture lies more in better management of existing resources than in introducing new varieties of grasses, which, even if found suitable, would be subject to the same limited supply of moisture as those now growing there. Better management in this case would consist of more moderate grazing and less trampling by stock, also the prevention of fires as far as possible, and the covering of bare places with light manure, coarse wild hay, cornstalks, or litter of any sort that would help to hold the loose soil from blowing, and provide a lodgment in which seeds could take root.

A good deal has recently been written about the value of sweet clover for sowing in bare sandy spots and blow-outs, and many experiments with it for this purpose have been made at the Substation but without much result. Where sand has drifted on to a clayey subsoil or where sand has been blown off and left a hardpan subsoil exposed, it has been found that sweet clover will take root and flourish if it gets into contact with the subsoil; but where the sand is deep and dry, very little success has been attained even when assisted by a mulch of manure or litter. In such situations, weeds of various kinds often do well, and if the seeds of these are encouraged to grow they will frequently take root and help to bind the sand. Work along this line has brought better results than trying to grow sweet clover in such places. Objection might be raised to growing weeds, but the main thing to do with a blow-out is to stop it if possible. Little fault is to be found with the quality of summer pasture in the Sand Hills, as stock fatten rapidly on it whenever there is abundance for their requirement.

IMPROVING WINTER FEED PRODUCTION.

Fortunately the question of improving winter feed by the introduction of tame or imported varieties of forage or hay-producing plants is very much more simple than that of the improvement of pastures. As pointed out, progressive stock owners are doing so by introducing such leguminous plants as red clover and alsike into their meadows by simply scattering the seed on the surface early in spring and letting the weather work it into the ground. Alsike has been found best suited to the lower lying situations, and red clover to the drier parts of the wet valley hay meadows.

On dry valley bottoms, alsike is not suitable, but red clover seeded in the meadows does very well after it has once obtained

a stand. In such situations it has been found advisable to plant it (1) with a disk drill, having previously removed the press wheels, or (2) by diskking the sod with a common disk and sowing broadcast. In the latter case a good deal of seed is lost, as all does not hit the disk cuts or trenches. Red clover seeded in native grass meadows at the Substation on what may be classed as dry valley bottom land has increased in quantity every year, producing an abundance of seed and reseeding itself. Sweet clover is also easily seeded in native hay meadows. While to a certain extent it must have reseeded itself in the meadows here, it does not thicken to the same extent as red clover. At the Substation this is considered fortunate, and it is hoped that it will soon disappear, as it is looked upon as a detriment to any meadow, having passed the proper stage for harvesting long before the haying season is on. Its woody stalks look like large last year's weeds among the grass and would detract from the selling value of the hay. Alfalfa has been seeded in the meadow here in the same way as described above in the case of the clovers, but made no stand. Red clover alone has increased the value and quantity of hay cut and justified the cost of seeding in a dry valley meadow. The quantity of seed required if a good stand is wanted at once is about the same as should be used when seeding on tilled land, as much of it is lost under the conditions of meadow seeding. Under favorable conditions, a full stand can be obtained when seeding clovers on sod by using either 8 pounds of alsike, 12 pounds of red clover, or 25 pounds of sweet clover per acre. It should be remembered that alsike is best for very wet land only, and that sweet clover is objectionable for the reasons given above, in either wet or dry valley meadows. Much lighter seedings than those aforementioned can be used, of course, if the owner of the land is content to wait until the clover gradually thickens as it seeds itself. All work of this kind should be done as early in the spring as possible, as the clover seed has then a better chance of connecting with the soil than when the ground is dry and hard. The young clover also does not have to compete with the growing grass so much as if it were sown later. At the Substation in the spring of 1915 an experiment of sowing patches of red clover on the meadow just before the snow had quite disappeared was tried. No preliminary preparation of the ground had been made for this purpose. The practice has not given good results. On reclaimed wet valley land, however, the soil conditions are more favorable for sowing on top of the ground.

ALFALFA IN THE SAND HILLS.

If red and alsike clovers find their best application in the wet valley meadows of the Sand Hills, where no cultivation accompanies their seeding, alfalfa is undoubtedly the chief leguminous crop of the dry valley and bench lands as well as of the heaviest class of dune sand land. Realizing this, more work has been done with alfalfa than with any other single crop. At the time this Substation was established, a limited amount of alfalfa was being grown thruout the Sand Hills; and while, in the opinion of those best qualified from their acquaintance with it to judge, it was considered an entirely successful crop, a large number of people were more than doubtful as to the advisability of trying to grow it. But within the last few years this doubt has disappeared, and it would be hard now to find a settler who is not either already provided with a patch of alfalfa or planning to get one.

Experiments have covered pretty fully the following points of investigation:

1. Character of Sand Hills soils on which alfalfa will succeed.
2. Tests of varieties for Sand Hills.
3. Comparative tests of varieties of alfalfa with some clovers, especially with sweet clover, as to drouth resistance on light soils.
4. Depth at which seed should be placed in light soils.
5. Amount of seed per acre and best method of sowing and covering.
6. Comparative tests of spring and fall seedings.
7. Experiments with inoculation.

The results of the investigation indicate the following:

Subirrigated dry valleys with permanent water not less than 6 feet from the surface make the best alfalfa ground. On such ground, generally speaking, there is little difficulty in getting stands of alfalfa. As far as is known, alfalfa on such land is reasonably permanent, being less so as the distance to water decreases. On such land at the altitude of the Substation (2,859 feet) three and sometimes four crops—totaling, on an average of two years, a yield of over two tons per acre—have been cut each year. On bottom land, not subject to subirrigation, the yield is lighter, and the number of cuttings is less.

On the better class of dune sand land two light cuttings a year and in some years one, have been sufficient to exhaust the moisture in the soil. As showing what land of this class will do under more abundant moisture conditions, at the Substation this year (1915) four cuttings of alfalfa have been obtained from one and a quarter acres, totaling in weight of cured hay 8,475 pounds, or at the rate of 6,780 pounds₄ per acre.

VARIETY TESTS OF CLOVERS AND ALFALFAS ON LIGHT SANDY SOIL.

The variety tests of clovers and alfalfas were begun on light sandy soil in 1910. The land was broken from sod about the end of June of that year. The work was not well done, as the surface sod had dried out and was difficult to break. The ground immediately after breaking was disked twice and harrowed. Seed was broadcasted with a hand seeder and covered by harrowing. The work of seeding was done July 2, following a heavy rain. The plots were half an acre in size. No cutting was done the first year. Few weeds grew, and the land was covered before frost with a light dressing of manure put on with the spreader at the rate of six loads per acre, to help in protecting the young plants from frost.



Fig. 4.—Dry land alfalfa field.

The depth of covering was about the same for all except that the unhulled sweet clover seed was planted deeper. The first table gives the time taken to germinate and the percentage of stand one month later. The rain during July, 1910, amounted to 2.14 inches, making the moisture condition favorable for obtaining stands of alfalfa or clover.

TABLE 2.—*Results of variety tests of clover and alfalfas on light sandy soil.*

Variety	Date of sowing	Date of germination	Nature of stand August 2
	<i>July</i>	<i>July</i>	<i>Per cent Full stand</i>
Grimm alfalfa	2	10	85
Common alfalfa	2	10	75
Turkestan alfalfa	2	12	55
Red clover	2	8	50
Alsike clover	2	8	15
Mammoth clover	2	10	30
Sweet clover	2	27	

Later, the sweet clover thickened to 60 per cent, subsequently to what appeared to be a full stand. On the other hand, all the other clovers thinned out more or less. Alfalfas held their own. No mowing was done the first year, but one mowing was done the following year, 1911. The dry weather succeeding the first mowing and lasting during the whole of June, July, and well into August, scorched the plants to such an extent that they did not recover until late in the fall. The fall of 1911 was damp, and subsequently these made strong growth and went into winter in good, strong condition with the exception of the alsike and mammoth clovers. The following yields were secured from the first cutting, which was made June 22, just as the dry weather began to affect the growth:

Variety	Pounds hay per acre June 26, 1911
Grimm alfalfa	1,580
Common alfalfa	1,550
Turkestan alfalfa	1,240
Red clover	800
Sweet clover	1,560
Alsike clover	too poor to cut
Mammoth clover	showed only a few bunches and was not cut

The weather for six weeks succeeding the harvesting of the foregoing was the driest on record for the time of year. This burned down the crop to such an extent that little recovery was made till October, in spite of a wet fall, and no more harvesting was done. The following spring, 1912, it was found that the mammoth and alsike clovers had almost disappeared and that the red clover was also much reduced in stand. The alfalfas and sweet clover stood the winter well and the former was twice

harvested, but the second crop of sweet clover was allowed to seed out as given below:

TABLE 3.—*Comparative yields of alfalfa and sweet clover, 1912.*

Variety	First cut in lbs. June 22	Second cut in lbs. Aug. 26	Total per acre
Grimm alfalfa.....	1,340	700	2,040
Common alfalfa.....	1,180	400	1,580
Turkestan alfalfa.....	960	300	1,260
Sweet clover.....	1,325	not cut	1,325

The reduced cutting in June from that of the previous year was undoubtedly due to the continued scarcity of moisture. A shortage of 11 inches from the average was registered in the period covered since these crops were sown. The average precipitation in this district covering a 25-year period was 22.46 inches, while in 1910 it was 18.45, in 1911, 17.09, and in 1912 only 15.99 inches.

The sweet clover made a satisfactory second growth but was not cut, in order to give it an opportunity to re-seed, which it did, but this failed to germinate. Possibly the drouth of the succeeding very dry season was the cause for the failure, altho it has subsequently been found that sweet clover fails quite frequently to re-seed itself on this class of land.

The field was converted into a horse paddock in the fall of 1913, and in 1914 the alfalfa which was the last survivor of all the varieties tested had itself mostly disappeared.

In the foregoing it will be observed that the variety known as Grimm alfalfa has apparently stood the test of extreme dry weather better than the others, yielding more than either the common or the Turkestan. This apparent superiority of Grimm alfalfa, however, has not shown in more extended tests, common alfalfa yielding just as well in general. In the case of the depth seedings as exhibited in Table 4, where careful records of yields were kept, it will be found that those from common alfalfa considerably exceed those of the Grimm variety. Grimm alfalfa has shown a rather finer quality of hay at the Substation, but whether this is an inherent quality or due in this case to some other cause has not been determined.

The foregoing is only one out of about 40 parallel experiments in seeding alfalfa and sweet clover, which have led to the conclusion that alfalfa will grow on sandy soil wherever sweet clover will.

Furthermore, some of these experiments show that it will grow where sweet clover sometimes fails, and that for general purposes it is the best and most profitable leguminous crop that can be raised on cultivated land within the Sand Hills area. No inoculation was given the seedings described above. So far, then, as the experiment goes, it went to show:

1. That alfalfa will grow well on sandy soil without inoculation.

2. That alfalfa is fully as hardy under trying Sand Hills conditions as any of the clovers, including sweet clover, with the advantage over the latter that the alfalfa does not need to re-seed, while the other does and in this case failed.

3. That as the years in which the experiments described were conducted were years of small precipitation, averaging approximately 6 inches a year below normal, it is probable from the showing here made that a ton and upward of alfalfa could be cut per acre in an average year, and that on light sandy ground, such as is to be found almost anywhere in the Sand Hills country.

4. That while the table given here shows the heaviest yield in the case of Grimm alfalfa, this has not been the case in more extended tests in which common alfalfa has yielded as well and in some cases even better than the Grimm variety.

DEPTH FOR PLANTING ALFALFA SEED ON DRY SANDY LAND.

The question as to what depth alfalfa seed should be planted on dry sandy land is one which is very frequently asked, and at the Substation some experiments to determine this important point were undertaken. In order to make sure that the seed was being placed at known depths, the Brott method of row seeding was adopted. This is a method of seeding alfalfa originated, or in any case brought into prominence, by Mr. Lewis Brott, a farmer who resides near Sextorp, Cheyenne County, Nebraska, who has been successful in raising alfalfa seed on high, dry uplands, and who has published a pamphlet describing his methods. It is substantially as described below except that Mr. Brott advises much heavier seeding. The distance between his rows also is less than the 42 inches adopted for convenience at the Substation.

The corn planter is fitted with wooden slippers, which can be adjusted on the stub runners at any depth required. Onion seed plates with a brush cut-off are then used in place of the ordinary corn drop plates. The seed was deposited at the rate of from 3 to 4 pounds per acre, at depths varying from one-half inch

to 6 inches. The corn planter was not altered to give narrower rows, so that the distance between these was 42 inches. The work was done on a very light sandy loam. The three varieties of alfalfa mentioned in the previous experiment were used in duplicated plots of one-tenth acre each. The weather succeeding sowing, which was done near the end of June, 1911, was exceedingly hot and dry, the precipitation for that month being only 0.99 inch, while the next month had only 0.68 inch.

Under these conditions broadcasting alfalfa on this class of land was a complete failure. Seeding by the corn planter method was a failure at a less depth than 1 inch, and also at depths below 4.5 inches. The table given below will show the further results. It is assumed that there are 4,200 feet of row in an acre when rows are 42 inches wide. This is close enough for this comparison. The combined rainfall of April and May previous to harvesting totaled slightly over 6 inches, while June was hot and dry with little over 1 inch. Cultivation between the rows was given with a five-shovel one-horse cultivator early in April when the plots were also cross harrowed with a drag. A second cultivation, but without harrowing, was given during the second week in May. The plots were mowed on June 17 and harrowed as soon as the crop was harvested. Subsoil moisture was scarce, and this combined with scorching weather after harvesting, gave the second growth a poor start which the copious rain of July did not fully recuperate. No second cutting was made, and in August the plots were turned into a hog pasture and grazed down. Below will be found the yield from the various depths of seeding.

TABLE 4.—*Comparative yield per acre of alfalfa planted at various depths. 1913.*

Variety	1 inch deep	1½ inches deep	2 inches deep	2½ inches deep	3 inches deep	4 inches deep
	<i>Lbs.</i>	<i>Lbs.</i>	<i>Lbs.</i>	<i>Lbs.</i>	<i>Lbs.</i>	<i>Lbs.</i>
Grimm alfalfa	1,420	1,580	1,620	1,160	1,390	800
Common alfalfa . . .	1,590	1,480	2,040	1,860	1,680	1,120
Turkestan alfalfa . .	950	1,160	1,220	1,300	800	Lost note

The foregoing would seem to indicate that, generally speaking, alfalfa seed is not sown deep enough on very light unretentive soils. It looks as if a depth of 2 inches is the best for seeding, and when it is remembered that the depths given above are in *compressed earth* this is all the more significant, as any depth in compressed earth may reasonably compare with a depth one-

half inch greater in loose soil. It should be noted that this seeding was done after the soil was thoroly warmed, and also that the weather was exceptionally hot and dry while the seed was germinating. Earlier seeding with cooler and damper weather might show something different from the foregoing. Generally speaking, alfalfa seed should be less deeply covered in the spring than later on, as the soil at that season is cold after the winter period, and seed sown too deeply is liable to rot. There is little danger of covering alfalfa seed too deeply with the drag on sandy land. At the Substation it has been covered by disking on this class of land and has done well.

RATE OF SEEDING FOR ALFALFA ON DRY SOIL.

In the spring of 1913, experiments were conducted to find the best rate of seeding on light, dry, sandy soil. Here again the three varieties of alfalfa already mentioned were used in duplicate one-tenth acre plots. The seeding of each of these was done at the rate of 2, 4, 8, 12, 14, 18, and 24 pounds per acre. The land broken in 1911 was planted to fodder corn, backset the following spring, was sown to rye, and grazed off and disked. Some manure was spread over it in the spring. After disking and working over, it was used for the purpose here indicated. In 1913, the alfalfa seed was sown broadcast and covered with a drag harrow. As dry weather followed the sowing, it was rolled. A stand was obtained on all the plots. This was clipped with the mower in the fall, as it had become weedy. The following year, 1914, it was cut once for hay, with the following results.

TABLE 5.—*Yield of alfalfa at different rates of seeding.*

Pounds per acre seeded	2	4	8	12	14	18	24
Grimm alfalfa.....	380	790	1,110	1,480	1,460	1,600	1,440
Common alfalfa.....	440	920	1,220	1,540	1,600	1,410	1,400
Turkestan alfalfa.....	300	500	980	1,250	1,120	1,180	1,060

These figures show the best seeding to be between 12 and 18 pounds. This has been found correct on this class of soil in other work at this Substation, and seeding is now done at about 15 pounds per acre on well-worked and packed soil. Much depends on the soil being in good tilth. Seed can be saved by sowing on a good seed bed, as less of it is lost in good, firm soil. The reader

may compare the heaviest yields in the above table with the heaviest yields when sown in the row system as recommended by Mr. Brott. It will be found that the row system gives the heavier returns. It is not believed, however, that this would be the case in richer or moister soil.

These experiments are not strictly comparable, because the latter was conducted one year later than that with the alfalfa in rows. Aside from this the rainfall in the latter year, that of 1914, during the months preceding harvesting was favorable to the yields from the plots sown broadcast, being slightly greater. But they go to show that the space left between the rows is not lost ground when growing alfalfa on dry soil, and this finding has been sustained by other experience obtained here.

INOCULATION IN ALFALFA CULTURE.

Experiments with inoculated alfalfa seeds and soils have been conducted here. The ground chosen was somewhat heavier and lower lying than the light sandy land on which all the previously described experiments were conducted, but was not subirrigated. Both Grimm and common alfalfa was used. Strips of one acre each were inoculated with soil from an old alfalfa field, and seed for two more acre strips was inoculated with cultures supplied by the Bureau of Plant Industry, United States Department of Agriculture. Along with these, two more similar sized strips that had neither the seed nor the soil inoculated were sown. No records of the yields from these strips were taken as no apparent difference could be observed, either in their appearance or in the yields from them. This result is in line with all the work done with alfalfa at this Substation on whatever class of land it is sown. Bacteria can be found on the roots within a short time after the plants are up, which would indicate that the nitrogen-producing organisms are present in the soil and that inoculation is unnecessary.

ALFALFA AND SWEET CLOVER.

While in recent years sowing sweet clover has been much recommended for Sand Hills land, on account of its alleged ability to grow where alfalfa will not, experiments here have not shown that it has any such advantage over alfalfa. Out of a large number of experiments conducted here during the last three years there is not a single instance of sweet clover having succeeded where alfalfa failed. On the other hand, there are at least three instances of sweet clover having failed where alfalfa succeeded. This refers only to sandy soil. One case at least is known to the

writer in which sweet clover succeeded where attempts to grow alfalfa failed. The ground in this case was a shallow, sandy loam with a stratum of hardpan underneath which prevented the water below it from rising. The sweet clover flourished in this situation, probably because its roots succeeded in getting thru the hardpan.

Tests with sweet clover seed at this Substation have shown that only about 60 per cent of the sweet clover grows. Where alfalfa is sown at the rate of 15 pounds per acre, it is safe to sow sweet clover at the rate of 25 pounds. This and the higher price of the clover makes sweet clover seeding expensive. This spring (1915) alfalfa seed was bought for \$6 per bushel, the price of sweet clover being \$9 per bushel. Quite recently sweet clover sold for more than double the price of alfalfa seed. But taking it at the figures quoted above, and seeding in the proportion given, we have the cost of seed for seeding 1 acre with sweet clover \$3.75; cost of seed for seeding 1 acre with alfalfa \$1.50 or two and one-half times greater cost in the case of sweet clover.

Generally, stock prefer alfalfa, at least before they acquire a taste for sweet clover. At the Substation, hogs spend more time grazing on the sweet clover than on the alfalfa patches. Other farmers have the same experience, while others again report that their stock will not eat sweet clover either as hay or as pasture. No one ever complains of stock refusing alfalfa if it is properly cured.

Following will be found a series of six different tests of six different samples each of sweet clover seed and of Grimm alfalfa, common alfalfa, and Turkestan. These tests seem to indicate a very low germination for sweet clover. In actual work, however, sweet clover would show over 100 per cent higher than is indicated here, as a large proportion of the seed is "hard-shelled" and takes longer to germinate than the time given in these tests, which were read eight days after putting to test. How long it takes hard-shelled clover seed to germinate has never been determined here.

TABLE 6.—*Germination tests of alfalfa and sweet clover.*

Test No.	Grimm alfalfa	Common alfalfa	Turkestan alfalfa	Sweet clover
	<i>Per cent</i>	<i>Per cent</i>	<i>Per cent</i>	<i>Per cent</i>
1	94	98	86	32
2	87	92	78	17
3	93	89	82	42
4	75	99	69	23
5	94	91	90	35
6	93	87	82	26

HOW TO KEEP A STAND OF ALFALFA.

There have been more reports received at this Substation of failures to keep young stands of alfalfa than of failures to obtain them. On our sandy soils, loss in this way can usually be attributed to one of three causes. These are (1) sun scorching, (2) soil blowing, and (3) loss from drying out, which in the case of young stands frequently takes place some time during the fall, winter, or early spring, and is often but wrongly supposed to be caused by frost and the severity of winter weather. This is natural, as it is usually early in the spring that the trouble is discovered, which leads to the supposition that the damage has been caused by the cold of the preceding winter.

To these may be added another trouble which has been very apparent in work with alfalfa this year (1915), viz, failure of the alfalfa when in its two leaf stage, or when it is from two to three weeks old, to survive, evidently after it has used up the plant food in the seed. Apparently this failure is not entirely due to drying out, as it occurred this spring while the surface of the soil was constantly damp, as well as in drier weather, and is probably caused by its failure to secure plant food from the soil. This occurred only on the lighter soils.

NURSE CROPS IN ALFALFA GROWING.

A nurse crop is the most frequently suggested remedy for the first and second of these troubles. Experience here has shown that a nurse crop is a worse evil than the trouble it is intended to cure. While it may to some small extent prevent soil blowing, and will also help in providing shade for the young slower growing alfalfa, it will certainly compete with the latter for whatever moisture there is in the ground. On dry, sandy land, soil moisture is the one great necessity of which there is seldom an abundance. In more humid climates, or where moisture can be controlled, as in irrigation, the sowing of a nurse crop with alfalfa or clover is a good practice, and frequently works for the benefit of the alfalfa crop, as well as being otherwise profitable. On sandy soil it is better to grow some sort of small grain, or even corn or cane, as a nurse crop the previous year. In the case of small grain it should be so cut as to leave a long stubble, and unless the soil is very loose it ought to be disked as soon after cutting as possible, taking care not to level too much of the stubble. Left in that condition all winter it will catch and hold snow, which will drift into the stubble and stay there. The disking, by loosening the ground, will help to admit the moisture freely. A second disking might be given as early in the spring as

the ground will permit. This will assist in retaining the moisture by forming a mulch. When the ground has become warm, the alfalfa can be seeded, preferably with a disk drill, having the press wheels removed. Enough stubble will be left standing after all the work has been done to help materially in breaking the wind, and thus prevent soil blowing. It will also give some shade to the young plants and will not take up the moisture accumulated in winter as a nurse crop would do. This plan has been tried here and is one of the most successful for the purpose. Where corn or cane has been grown and cultivated, it is frequently possible to sow alfalfa seed about the first week in August and cultivate it in when the corn is being put away. Last year a good stand was obtained on a farm near the Substation by sowing and covering with the last cultivation given to the corn. Cultivated corn land is not so liable to be dried up as land which has just grown a small-grain crop. Consequently it is less necessary to wait for the winter moisture before sowing as was recommended in the case of seeding after a small-grain crop. No experience along this line in sowing after cane has been had at this Substation.

PREVENTION OF SOIL BLOWING.

Light dressings of manure are frequently recommended for the purpose of preventing soil blowing in newly seeded alfalfa fields. This plan has been frequently tried at the Substation by spreading the manure before the alfalfa came up, and in other cases after it had appeared. It has never worked successfully. Unless the manure is laid on thick enough to prevent all soil movement, the soil drifts and forms wreaths or banks deep enough to bury the small alfalfa plants. The soil is thus left with its surface covered with little banks. Stubble, on the other hand, by breaking or sifting the wind, reduces its velocity at the surface of the ground but does not bank up the soil by stopping it altogether as does manure. This is not meant, however, to detract from the value of manure as a preventer of soil blowing. It is all right for that purpose when applied to crops that are less easily buried than young alfalfa or to such plants as may be lightly covered after they are once up and are of a stronger, more rapidly growing nature than alfalfa in its early stage of growth. Manure may also be applied to fallow land to prevent soil blowing. But the best way of all to use manure on such land is to get it into the soil as humus, where it will act against soil blowing both by making the soil more fibrous and by tending to keep it more moist as well, and where it will also be useful on account of its fertilizing properties.

THE BEST TIME OF YEAR FOR SEEDING ALFALFA.

In this section of country there are four months to choose from during which alfalfa may be seeded with reasonable hope of success, these being May, June, July, and August. Seeding earlier or later than these months might possibly succeed, but the chances of success would be reduced. Subdividing the above period, the best parts of it would be from the middle of May till the middle of June, and again from the first till the middle of August. The former period would come within the term of spring sowing, while the latter might be called fall sowing. Where alfalfa is sowed on newly broken sod, June is probably the best month for sowing. The work should be done as soon after breaking as possible, and June is the best month for breaking. When the breaking and other preparation of the land is well done it is usually easy to get a stand of alfalfa on sod. But for soil that has been under cultivation for some time it has been found in recent years that fall sowing is better. If the precipitation record on page 12, is studied, the reason for this will be apparent. During the last five years more rain has fallen on an average during the month of August than in any other month, and as is well known, the wind movement in August is much less on an average than it is in the earlier part of the summer. Moreover, while the heat of August may appear as oppressive as it is in June, the direct rays of the sun are very much weaker, and the daily period of sunshine considerably less. All these circumstances—less wind, less sunshine, and more moisture—are favorable to the growth of a stand of young alfalfa under Sand Hills conditions. Whether wetter springs and drier falls might shift the advantage to spring sowing, it is impossible to say positively. Again, at the Substation, showery weather used to be waited for before sowing alfalfa seed. Now, if the ground is fairly dry and there is not too much fear of soil blowing, the seed is put into the seed bed, and is there, ready to take advantage of the first rain that comes. Alfalfa seed does not spoil by lying in dry ground. It spoils by drying after having had sufficient moisture to start growth.

ROLLING NEWLY SEEDED ALFALFA LAND.

Rolling ground which has recently been seeded to alfalfa—either as a method of covering the seed after sowing, or as a means of firming the soil about the newly sown seed or young plants in dry weather (in order that by restoring the capillary action of the soil the moisture from beneath may rise and supply the deficiency at the surface caused by lack of rain)—has fre-

quently been tested, sometimes with very good results. In using a roller for this purpose, it is better to cross the field, as by so doing the roller is brought in contact with more of the surface of the field than if it were used lengthwise of the lands.

Rolling has been resorted to in order to help cover broadcasted alfalfa seed on rough or stubbly ground. We have a number of plots of both alfalfa and sweet clover at the Substation that were preserved by rolling at the right time, while the alfalfa sown on similarly planted plots that were not rolled never germinated.

There is less risk attached to the practice of rolling fall seedings. At that time there is likely to be less wind to sweep the soil, the surface of which has been left smooth and pulverized by the roller. Rolling, of course, is also less risky when done on weedy or stubbly ground for the reason that the wind cannot sweep such so severely as it can clean land. Rolling can generally be done in the Sand Hills with less chance of harm—apart from that caused by wind—than on soils that are heavy or clayey, as there is less tendency to glaze or bake in the light sandy soils of this section.

ROW CULTIVATION OF ALFALFA.

Reference has already been made to the practice of seeding alfalfa in rows, when discussing the experiments made to determine the best depth at which to seed alfalfa. In these operations the seeding was done with a corn planter, fitted with slippers on the stub runners as previously described, in order to insure accuracy of depth, and for the purpose of packing the soil along the seed rows.

No other method of seeding alfalfa on light sandy soil tried at the Substation has been found so successful as this in getting seed to germinate promptly. This is due to the fact that it can be placed at exactly the depth judged to be best under the local conditions. At the same time, the soil on either side of the row has all the advantage of having been rolled without the disadvantage of having the entire surface of the field pulverized and made more liable to damage from sweeping wind and from loss of moisture as the result of increased capillary action due to rolling. Also, the tracks of the slippers form shallow flat-bottomed furrows, and if the rows are run as they should be—at right angles to the direction of the prevailing winds—these afford some shelter for the plants in the first stages of their growth.

While this method of seeding is, as has previously been stated, more certain of success than drilling, or broadcasting on light sandy soil, it is one better adapted to alfalfa being grown for

seed production than for hay. In the latter case, especially when the rows are cultivated, it is impossible to harvest the hay in dry weather without getting it badly dusted while raking it up. Cutting with a dropper attached to the mower has been tried but does not work well, as alfalfa will not slide like grass, and if heavy will not cure evenly in the dropper windrows. On the other hand, when grown for seed, there is less objection to dust, as it can be eliminated from both seed and straw in the process of threshing.

The advantages claimed by advocates of rowed alfalfa—that it can be thoroly cultivated without damage to the crowns—has been met by the introduction of the drag-bar and other improved alfalfa cultivators, and the only advantage claimed here for the row method of seeding is its greater certainty.

The ordinary width of the corn planter—42 inches—is much too great, especially where it is not the intention to cultivate along the rows, but this can be overcome by setting the seed plates to drop the seed more thinly, and, after going over the field once, straddle the rows with the planter and go again, thus reducing the width of the rows to 21 inches.

At the Substation certain good results have followed the use of disk openers on the corn planter when seeding in alfalfa. These have been experimented with in opening furrows from 2 inches to 6 inches in depth, at the bottom of which the seed was sown in the trenches made by the stub runners. Slipper attachments are unnecessary when sowing by this method, as the disks take the weight off the stub runners, thus preventing them from cutting too deeply. A ring, or a drag made of a chain or other material attached behind the stub runners so as to drag along the bottoms of the furrows, will be useful in helping to fill in the seed trenches and cover the seed. Up to a depth of 4 inches it is possible to open the furrows and sow the seed at the same time, but for greater depths of furrow it will be better to open the furrows first to the depth desired, and then remove the disks and sow the seed in the ordinary way with the corn planter. When sowing in furrows, no slipper attachments will be needed, as the compact soil at the bottom of the furrows will prevent the stub runners from cutting too deeply.

It has been found that alfalfa sown in this way has proved more drouth resistant than when sown at the surface either by broadcasting, drilling, or the Brott method. While no comparative yields from the various methods have been tabulated here, still it has frequently been observed that alfalfa which has been sown as here described remains greener in the fall and recovers earlier in spring from the effects of winter. Probably the reason for this

is because of the protection afforded the alfalfa crowns by the filling in of the trenches with soil, thus giving them more immunity from unfavorable weather conditions, such as scorching heat or cold.

On the other hand, it has been found that alfalfa sown in this way takes longer to arrive at a full crop producing stage than when sown by other methods. The increased labor involved, and this weak initial growth, preventing as it does early cultivation for the purpose of checking weeds, for fear of covering up the young plants, are serious objections to this method.

Alfalfa has been sown here by using the common two-row lister with onion seed plates and brush cut-off attachments and planting the seed at the bottom of the lister furrows. This is much the same as using a corn planter with disk openers as aforementioned. Still another method is to use the disk or other drill, stopping a sufficient number of the seed spouts between those left open to give the desired width between the rows.

It should be kept in mind that all of the foregoing discussion relates to the seeding of alfalfa on light sandy soil in a dry climate, also that sowing alfalfa seed in furrows as described is more safely practiced in early fall than in spring, as the ground at the latter season is more thoroly warmed, and, besides, there is much less likelihood of the wind blowing the soil into the furrows and covering up the young plants.

It should also be remembered that the foregoing is applicable only to soil that has been previously in cultivation, and that with soil of the description under investigation, unless special means are taken to prevent the loss of humus, the difficulty of establishing a stand of alfalfa on such land generally increases in proportion to the number of cultivated crops that have been grown upon it.

SEEDING ALFALFA ON SOD.

Under advice given out as the result of experience obtained here, the practice of seeding alfalfa on freshly broken sod is increasing, and with gratifying success.

While failures to obtain stands of alfalfa on land that has previously been cultivated are numerous at this Substation on the lighter soils, there is no record of a failure to establish a stand on lands of corresponding quality when the work was done on newly broken sod. Of course it is not meant to convey the idea that any freshly broken sod land will grow alfalfa, because land for that purpose should be chosen as carefully as if it were intended for any other crop.

One objection frequently made to the practice of seeding on

sod is that the grass is likely to come back and kill the alfalfa. This has not been noted here to any extent. Probably a good deal depends on the nature of the sod before turning it over, but the trouble more frequently arises from poor breaking. When breaking sod for any purpose, but particularly for alfalfa, the "cut and cover" system ought to be avoided and a complete severance effected between *all* of the sod and the sole or part immediately under it. When this is done, and the upturned surface properly worked down with disk and drag, there is little fear of interference from grass.

Some of the advantages of seeding on freshly broken sod may be mentioned. Probably the greatest of these is that there is likely to be little or no soil blowing, owing to the fibrous nature of the sod soil. Another great advantage is that there will be little or no competition from weeds during the first season, and another that freshly broken sod is a great conservator of moisture, which is sure to be found even in the driest seasons just beneath the cut or slice. Still another advantage of seeding on fresh sod is that by so doing, it is possible at the same time to get a crop of sod corn, as the objection to a nurse crop previously cited does not obtain to any injurious extent, at least with corn.

CULTIVATION OF ALFALFA.

Experiments conducted in the cultivation of drilled and broadcasted alfalfa in comparison with alfalfa that had not been so treated showed little or no advantage from cultivation where the alfalfa was broadcasted. Rowed alfalfa, on the other hand, invariably showed improvement when cultivated. Probably one of the reasons for this finding is because clean cultivation of rowed alfalfa had the effect of destroying most of the weeds between the rows, and also of establishing a mulch on a surface which, from exposure to the sun, would otherwise have been baked. It thus has the effect of conserving moisture. The average Sand Hills soil is naturally loose, and cultivation makes dusting of the hay at harvest time unavoidable.

PREPARATION OF GROUND FOR ALFALFA.

As previously stated, it is good practice to seed down freshly turned sod. When land that has been cropped has to be plowed for alfalfa it is, however, much better that the plowing be done the preceding year, so as to give the soil time to pack and settle, provided that by so doing it will not interfere with the retention of moisture by turning under stubble and other roughage which might otherwise intercept drifting snow and also keep the soil

from blowing. Where danger of doing so is present, it might be better practice to defer plowing until early spring, and by extra work with the disk run almost straight, and with the drag harrow, work the soil to a compact seed bed.

Generally speaking, Sand Hills soils are friable and not at all liable to clod, so that they exclude many air spaces by packing easily under such pressure as is given by the trampling of teams and the working over with the above-named or other implements.

Alfalfa does well when seeded on land that has just raised a cultivated crop, such as corn or potatoes. Following such crops, no plowing is necessary, all that is required being that a proper seed bed be prepared by top working the soil. Good stands of alfalfa have been obtained here by broadcasting the seed before the last cultivation of corn and covering with the cultivator. This method is somewhat wasteful of seed but can be used successfully, provided the cultivator is not run deeply. A still better way of sowing would be to use a small disk drill, such as is used for sowing winter wheat in a standing corn crop, and seeding between the corn rows.

Potato ground could not be seeded in this way, nor in the fall, on account of harvesting the crop. Seeding would have to be done before the alfalfa could be sown, and this, except in the case of a crop dug for early marketing, would generally be too late for alfalfa seeding. In this section alfalfa seeding should not be attempted later than the end of the second week in August. In the Sand Hills it is frequently advisable to sow alfalfa in small grain or in cane stubble, but this has been discussed on page 31.

No other matter pertaining to Sand Hills farming rivals the subject of alfalfa in importance except perhaps the introduction of better and still better live stock. It is the writer's firm belief that there are few Sand Hills farms or homesteads, so poor but that a spot can be found within their 640 acres upon which alfalfa can be grown, if the work is gone about in an intelligent manner. Once a stand of alfalfa has been established, there is no other farm product possible to Sand Hills conditions that will so well repay the labor that has been bestowed upon it.

OTHER PERMANENT FORAGE CROPS.

Some work has been done with permanent forage crops other than clovers and alfalfas, but the results have not been important.

Timothy will grow freely almost anywhere in the wet valley region, provided the land is not too wet. It also does well on subirrigated dry valleys. On the drier parts of these, brome grass does very well. The following experiment was carried out

on light sandy upland for the purpose of determining the most drouth-resisting grasses. In cooperation with the Bureau of Plant Industry, Washington, D. C., awnless brome (*Bromus inermis*), slender wheat, tall oat, western wheat, and orchard grasses were sown on one-tenth acre plots in 1912 but made so poor a showing owing to the drouth of that year that it was believed that the experiment had been a failure. The plots were mowed in the fall to kill any weeds that had grown, and left till the following spring, when the grass on three of them grew, the slender wheat grass making by far the best showing. The weather the year following that in which they were sown was again very dry, but cuttings were made with the following results:

Variety	Pounds hay per acre
Slender wheat.....	860
Brome grass.....	570
Western wheat grass.....	510

Both brome grass and slender wheat grass made a good fall growth, and the latter was quite promising in spite of the small return in hay as given above. Unfortunately, owing to a misunderstanding of instructions, these plots were plowed under early the following spring and lost. More seed was sown but it did not germinate, and the experiment has not been repeated.

ANNUAL FORAGE CROPS IN SAND HILLS.

It is quite unlikely that any great increase in quantity or that a better quality of hay could be got from seeding any known grass on the drier cultivated lands of the Sand Hills country. Methods have already been indicated whereby wet valley hay may be improved. If, therefore, forage crops other than sweet clover and alfalfa are to be grown in such situations, it would seem that dependence must be put on annual cultivated crops such as corn and cane, millet, rye, white spring emmer (spelts), and other small grains to be cut for hay. In the Sand Hills, the great objection to these as compared with such a crop as alfalfa is that the soil cultivation required to grow them soon destroys humus, with the result that the soil does not retain moisture as it should, and begins to blow. Alfalfa, being a perennial, once established lasts indefinitely, and can get along without cultivation. When a stand is once secured, it prevents soil blowing. No experiments have been carried out in this connection with the plants named above at this Substation for forage purposes, as their use and capabilities are well understood by Sand Hills

farmers. Some experiments have been carried out with various substitutes for the above forage plants. Thus far, however, Sudan grass alone has shown results which are worth mentioning.

SUDAN GRASS.

This recently introduced grass, as it is called, is a wild sorghum. In favorable years it produces abundant seed, which is not unlike flaxseed in appearance. As a forage plant it can be either sown in rows or broadcast. Sown in rows for forage, 5 pounds is sufficient, but if for seed 3 pounds is enough. On poor, light sandy land at the Substation, when sown in rows, it yielded seed weighing about 32 pounds per bushel and at the rate of 8 bushels per acre. For convenience, the same width between rows as for corn may be used. Sown broadcast at the rate of 24 pounds per acre, it was found to give a better yield of hay than when seeded heavier or lighter. Table 7 will give the yields from various methods of sowing, which was done near the end of May, 1913.

Experience obtained at the Substation in the production of Sudan grass seed during the season of 1915 was less encouraging. Selected local grown seed made a very poor stand, and failed to ripen. The stand from seed supplied by the Department of Agriculture, Washington, D. C., was better, but the seed from this also is immature. Undoubtedly the lateness of the spring had much to do with this result, but the experience has caused some doubt as to whether Sudan grass will maintain its native vitality under Sand Hills conditions.

A similar experience was had this year with feterita.

TABLE 7.—*Yield of Sudan grass hay from rows and when sown broadcast.*

Method of seeding	Rate of seeding per acre	Yield
	<i>Pounds</i>	<i>Pounds</i>
Rows, 42 inches apart.....	3	1,224
Rows, 21 inches apart.....	5	1,667
Broadcast.....	20	2,374
Broadcast.....	24	2,498
Broadcast.....	30	2,298

The hay from land sown broadcast was very foul, and probably 30 per cent of the weight ought to be deducted from the return of hay on that account. As a stock feed it is relished by all kinds of animals and is eaten with less waste than any cane that has been fed here. No exact record has been kept of the yield of

seed when sown broadcast, but from observation made on light land here, it probably averaged not less than 8 bushels of ripe seed per acre in 1914. Its chief importance in the Sand Hills is its hay-producing ability, and it is reassuring to know that it will be likely to be found producing an abundance of seed for planting.

GRAIN-PRODUCING SORGHUMS.

Grain-producing sorghums were tested at the Substation during 1911, 1912, and 1913. Most of the seed was furnished by the Bureau of Plant Industry, United States Department of Agriculture. Several samples of dwarf milo seed obtained locally were grown along with these as checks. The seed of all varieties was selected from heads showing early ripening qualities each succeeding year. Many of the varieties were unfitted for our northern climate and altitude and did not ripen seed. Returns from the best yielding varieties are given in Table 8.

TABLE 8.—*Yields of grain sorghums.*

Variety	Yields in bushels per acre		
	1911	1912	1913
Dwarf upright milo.....	5.8	5.0	11.2
Dwarf black hulled kaffir.....	4.0	3.8	9.2
Brown kaoliang No. 261.....	3.4	3.6	7.5
Brown kaoliang No. 328.....	3.8	4.0	5.2

Planting was done in rows the same as for corn, and with a corn planter. The rate of seeding was about 6 pounds per acre. Planting was done according to the seasons—first planting May 22, second May 27, and that of 1913 on June 1. Some of the kaoliangs are early, but they are low in yield. The marked increase in 1913 is due to the better season, when more rain fell than on either of the two preceding.

FETERITA.

On land similar to that on which the other grain sorghums above described were grown, feterita has shown remarkable drouth resistance, but has failed to mature seed properly, tho on richer soil it might do differently. As a forage crop it is poor, being strong stalked, with few leaves, and is woody and sapless.

It may seem surprising that milo should ripen seed when feterita failed to do so. This may be accounted for by the fact that the milo used in the tests was home grown and was therefore

acclimated, while the other was not. The 1913 seedings of grain sorghums were all later in maturing than in the previous years, and this circumstance without doubt also adversely affected the ripening of feterita. Also, it may not be quite correct to state that the feterita did not ripen, because some heads did apparently mature, and were preserved, and seeded the following spring, but made a very poor showing, presumably because even these picked heads were not quite mature.

In 1913, a cooperative experiment with seed supplied from the Substation, which was carried out on lower lying and much richer land in 1914, is reported as having yielded an estimated return of 30 bushels per acre. Some of the seed resulting from this test was secured and planted here but failed. The spring of 1915 was, however, very unfavorable to the culture of grain sorghums in the Sand Hills country.



Fig. 5.—Dry land cornfield in spring.

CORN IN SAND HILLS.

Because the cultivation of corn is one of the best understood crop-growing operations among Sand Hills farmers, comparatively little work has been done with it in an experimental way.

However, in 1911 in cooperation with the Bureau of Plant Industry, United States Department of Agriculture, which supplied some of the seed, varieties supposed to be suitable for Sand Hills conditions were planted. Three of these were of local pro-

duction and were placed in competition with the imported varieties.

The object of this experiment was, primarily, to ascertain whether a better yielding variety than the local ones could be found, and also to obtain corn yields for comparison with the grain sorghum yields, and those from small grains, all grown under almost identical conditions as regards soil and climate.

The local grown varieties were—a small yellow dent, the common main corn crop variety of the district; a white dent, somewhat larger and later than the yellow, also commonly grown over the Sand Hills section; and a calico corn. The dents obtained locally were variously named, scarcely any two persons agreeing on a common name for the same sample. In Table 9 the first three returns are from the local grown seed.

TABLE 9.—*Yields of corn.*

Variety	Yields in bushels per acre		
	1911	1912	1913
Small yellow dent, local variety.....	6.0	4.2	12.5
White dent, local variety.....	6.5	4.0	11.2
Calico corn, local variety.....	5.8	4.3	10.8
Minnesota No. 13, imported.....	a few ears matured	4.8	13.6
Australian white flint, imported.....	a few ears matured	3.6	9.0
Ardmore yellow dent, imported.....	failed		
Sels No. 13, imported.....	a few ears matured	3.9	record miss- ing

It is interesting to compare the above yields of corn with those of the grain sorghums already given, as well as with those of the small-grain yields given in Table 10 farther on.

As all of the years in which these experiments were conducted had less than normal precipitation and more than the average heat, it is presumed that the conditions were more favorable to grain sorghums than either to corn or to small grains, and when the risk of the former failing to mature in cooler seasons is taken into account the comparison is still more favorable to corn as a crop for the Sand Hills.

SMALL-GRAIN CROPS.

During the years 1912 and 1913 some experiments with small grains were conducted in cooperation with the Bureau of Plant Industry, United States Department of Agriculture, Washington,

D. C., from which most of the seed used was obtained, having been selected as varieties of small grains most likely to suit Sand Hills conditions.

The first season, that of 1912, was one of severe drouth, the precipitation being more than 6 inches less than normal, while the evaporation owing to high winds and hot sun was exceptionally great.



Fig. 6.—Oatfield on Substation farm.

The soil on which the experiments were conducted was similar to that on which the grain sorghums already referred to were raised. It is a light sandy loam with a subsoil of sand, and is entirely without subirrigation. It was broken from sod in the summer of 1910 and planted to corn, which was cut for forage. The ground was backset the following spring and cane was drilled in, which was cut in the fall for hay. Winter wheat and rye were sown in parts of it in October, 1911, being put in with a press drill in the cane stubble, which had previously been disked. The weather was favorable, as nearly 5 inches of rain had fallen in that month. The remainder of the ground was left in stubble until the following spring, when it was sown to the spring varieties of small grain here discussed. Considerable snow fell in March, 1912, and was well retained on the land by the cane stubble. The grains were drilled in one-tenth acre plots on April 3, the weather in that month being favorable as regards moisture, tho there was one rather severe freeze. Considerable rain fell in May, but drying winds were frequent. All grains, however, made a splendid start. The June rainfall was scant, while other-

wise the weather was hot, with frequent high winds. The weather in July was a continuation of the same, with still less rainfall than in the previous month.

Under these conditions the small-grain experiments were nearly all complete failures, and the only ones which were tabulated were Kharkov wheat, a winter variety, and the winter rye, and spelts.

In the following year, 1913, these experiments were repeated with the following results:

TABLE 10.—*Yields of small grains. 1913.*

Species or variety	Rate of seeding	Yield
SPRING WHEAT	<i>Pecks</i>	<i>Bushels</i>
Kubanka.....	3	5.9
Velvet Don.....	3	4.8
Galgals.....	3	5.4
WINTER WHEAT		
Kharkov.....	4	11.3
Turkey Red.....	4	10.0
Spring rye.....	3	8.6
Winter rye.....	4	11.8
Emmer, Lot 1.....	5	11.5
Emmer, Lot 2.....	5	10.8

An approximation between the yields of milo maize, winter wheat, winter rye, and emmer, as well as corn, may here be noticed, and by turning to Table 4 on page 27 a return of 2,040 pounds of alfalfa will be observed, but which was made in 1912. However, a record of alfalfa made the following year, 1913, from the same plots was kept. Two cuttings were made, amounting in all to 2,230 pounds, which may fairly be classified for comparison with the other yields, having been harvested in the same year and on similar land.

TABLE 11.—*Comparison of crop yields per acre in 1913.*

Highest yield of alfalfa, pounds.....	2,230.00
Highest yield of Sudan grass, ¹ pounds hay.....	1,667.00
Highest yield of potatoes, bushels.....	54.15
Highest yield of milo, bushels.....	11.20
Highest yield of winter rye, bushels.....	11.80
Highest yield of emmer, bushels.....	11.50
Highest yield of winter wheat, bushels.....	11.30
Highest yield of corn, bushels.....	13.60

No data are at hand for comparing the value of these various products nor the cost of their production. While these returns are small, it is questionable whether with the exception of alfalfa they could be duplicated on the same land under the same weather conditions, as the soil on which they were made deteriorates rapidly under cultivation, owing to waste of humus which it has been found difficult to replace fully, because the soil cannot assimilate barnyard manure except in small annual quantities, owing to moisture scarcity. Under such conditions and considering the various yields, it would seem that on this class of land, alfalfa would be the best crop to grow. On somewhat heavier soils manure and crop rotation will go a long way toward keeping intact the supply of humus.

Compared with the above yields of small grains, the return from an 8-acre field of oats sown in 1912 on the Substation farm on a piece of subirrigated ground may be mentioned. The yield from this field was 344 bushels, or 43 bushels per acre, and it will be remembered that 1912 was the driest of all years since the Substation was established, when the yields of the grain sorghums, corn, and small grains were less than half of those given above, which are the returns of 1913, a year more favorable for all crops in this section. The difference is, of course, due to the available moisture in the case of the subirrigated land on which these oats were raised.

The experience with small grains sown on light sandy soils which are not subirrigated would seem to point to the conclusion that they have little place in dry land Sand Hills farming, except perhaps for purposes of rotation, for which winter rye and emmer, grown to be cut for hay, would seem to be best adapted.

¹ The yield of 2,374 pounds hay from Sudan grass sown broadcast is subject to an estimated reduction of one-third, so that the return given here for Sudan grass, 1,667 pounds, is the yield from an acre sown in rows 21 inches wide.

Indeed, many experienced Sand Hills farmers are of the opinion that small-grain crops grown for their grain alone are not profitable, and when the small yields and the cost of the machinery needed for their production, such as seeding, harvesting, and threshing machinery, are considered, there is much to be said in support of their opinion.

POTATO CULTURE IN THE SAND HILLS.

Many inquiries are received at the Substation on the subject of potato growing, with special reference to the adaptability of the Sand Hills country for potatoes, and also as to the varieties best suited for local conditions.

The Early Ohio is the most widely grown of all potatoes in the Sand Hills, being, indeed, almost exclusively grown in many parts of it, and for this partiality there are good reasons. One of these is its earliness, which enables it to mature a crop before the soil attains its maximum heat in the early part of fall, at which time the immature potatoes of less early varieties are liable to be damaged by heat and the drying of the soil. Another reason for the popularity of the Early Ohio is its heavy yielding qualities. On the other hand, its color, which is red or pink, detracts from its value in the larger markets. It is besides quite susceptible to scab and other diseases, like stem rot, which have increased within the Sand Hills country during the last few years.

In order to obtain data on the subject, some experiments were begun in cooperation with the Bureau of Plant Industry, United States Department of Agriculture, which supplied most of the seed used.

A field broken from sod in 1910 was backset the following spring. The soil was of the lightest and driest description, being in fact just the better quality of dune sand land. After back-setting, a little manure was spread on top to prevent blowing.

One experiment was for the purpose of finding out the best depth to plant potatoes in such land. Another had for its purpose the ascertaining of the best distance apart in the rows, and another the size of seed best adapted to such conditions.

The 1911 experiments were a failure because of the want of rain in June and July, when the total precipitation for the two months reached only 1.07 inches. The work was continued during 1912 and 1913, when the seed being used was frozen in a cave which had hitherto been sufficient for winter preservation of roots. The results of the two years' work are given in Tables 13 and 16.

TABLE 12.—*Comparative yields in variety tests of potatoes. 1912-13.*

YEAR 1912						
Variety	Width of row	Length of row	Depth of planting	Yield per row	Total yield per acre	Market-able tubers per acre
	<i>Inches</i>	<i>Feet</i>	<i>Inches</i>	<i>Lbs.</i>	<i>Bu.</i>	<i>Bushels</i>
Early Ohio.....	42	42	3	27.5	45.8	41.5
Early Rose.....	42	42	3	23.4	39.0	36.5
Irish Cobbler.....	42	42	3	28.4	47.3	45.0
Eureka.....	42	42	3	26.2	43.7	41.0
YEAR 1913						
Early Ohio.....	42	42	4	26.4	44.0	41.0
Early Rose.....	42	42	4	24.5	41.25	40.0
Irish Cobbler.....	42	42	4	32.5	54.15	52.5
Eureka.....	42	42	4	24.6	41.0	39.4

1. The best depth was from 4 to 5 inches.

2. The best distance apart in rows of 42 inches wide was 24 inches.

3. The best size was a medium potato quartered.

Whole as well as half potatoes yielded a larger total crop and more marketable potatoes, but had more waste from unsalable, small, or deformed tubers, and the gain in yield scarcely made up for the extra outlay in seed. In a very dry year it is safer to try to raise potatoes from a smaller quantity of seed on the same principle that a thin crop of grain is less likely to burn up in dry weather.

TABLE 13.—*Comparison of yields of quartered Early Ohio potatoes planted at various depths.*

YEAR 1912				
Width between rows	Distance apart in row	Planting depth	Total yield per acre	Marketable tubers per acre
<i>Inches</i>	<i>Inches</i>	<i>Inches</i>	<i>Pounds</i>	<i>Pounds</i>
42	21	2	1,680	1,050
42	21	3	2,860	2,490
42	21	4	3,120	2,810
42	21	5	3,080	2,845
42	21	6	2,770	2,590
YEAR 1913				
42	24	3	3,060	2,620
42	24	4	3,190	2,980
42	24	5	2,870	2,790

Other than to show that the best depth for planting is about 4 inches, there is not much else to be gathered from Table 13 except that there is a greater proportion of unmarketable potatoes when planted at the lesser depths. Table 13 also shows that in the year 1912 the heavier yield was obtained from planting 5 inches deep, while the 1913 test shows a decided advantage from the 4-inch planting. Probably the difference in results is owing to the great humidity of the latter year. Some of the yields exceed those of Early Ohio in the variety test given in the table, but this is accounted for by the difference of the soils and other conditions.

TABLE 14.—*Comparison of yields of quartered Early Ohio potatoes from different spacings of potatoes along rows.*

YEAR 1912				
Width between rows	Space apart in row	Depth planted	Total yield per acre	Marketable tubers per acre
<i>Inches</i>	<i>Inches</i>	<i>Inches</i>	<i>Pounds</i>	<i>Pounds</i>
42	12	3	1,900	1,190
42	15	3	1,810	1,170
42	18	3	2,370	2,015
42	21	3	2,640	2,390
42	24	3	2,890	2,655
42	30	3	2,800	2,650
42	36	3	2,470	2,290
YEAR 1913				
42	18	4	2,595	2,315
42	21	4	2,575	2,345
42	24	4	2,995	2,855
42	30	4	2,480	2,330

The experiments, as will be observed from Table 14, are identical for the two years, 1912 and 1913, except that the spacing of 12 inches, 15 inches, and 36 inches were eliminated in the latter year, and the depth of planting was increased from 3 inches to 4 inches. The smaller proportion of unmarketable potatoes observed in 1913 may be owing either to the greater depth at which the sets were planted, or to the slightly more favorable potato season of 1913, as compared with that of the previous year. In 1913, the superiority of a spacing of 24 inches in its relation to the yield of marketable potatoes is more pronounced than in the previous year, tho this result would scarcely be expected on account of the greater moisture of 1913 which would

be reasonably supposed to favor of closer planting. It is possible that the more complete shading of the ground by the closer planting in 1912—a hot, dry season—had some effect upon the result.

TABLE 15.—*Comparison of yields of Early Ohio potatoes from various sizes of sets.*

YEAR 1912					
Size of sets	Width between rows	Spaced in row	Depth planted	Total yield per acre	Marketable tubers per acre
	<i>Inches</i>	<i>Inches</i>	<i>Inches</i>	<i>Pounds</i>	<i>Pounds</i>
Whole	42	24	3	3,770	3,290
Half	42	24	3	3,540	3,210
Quarter	42	24	3	2,890	2,655
Eighth	42	24	3	2,190	2,015
YEAR 1913					
Whole	42	24	4	4,140	3,775
Half	42	24	4	3,780	3,440
Quarter	42	24	4	2,995	2,855

In the above table it will be observed that the yields of marketable potatoes are larger in proportion in the latter year. Several causes may have contributed to this. There was more available moisture during the growing season for one thing. Another is doubtless the deeper planting practiced during the second year. In this connection it has been observed at the Substation that the depth of planting has very little effect on the depth which the crop occupies in the soil, when the tubers begin to set or form. But if the soil is hard beneath them, as it frequently is with shallow planting, they expand upward instead of more or less equally upward and downward, and this has the effect of eventually bringing them closer to the surface, where many of them become unmarketable thru sun scald.

Otherwise, the table shows that quartered potatoes are the best sized sets to use for planting under ordinary conditions, when the usual difference in value between potatoes at planting time and harvest time is considered.

VARIETY TESTS.

Variety tests were carried out with 12 varieties, mostly of early sorts. As was stated, the first tests were failures on account of dry weather in 1911. The tests were continued in 1912 and 1913 with the same seed.

The late varieties eliminated themselves by failing to mature in the first year, and no late varieties were planted in 1913. Only four of the early varieties are given below, and the figures are those of 1912 and 1913. The most successful competitor was the Irish Cobbler. This is a fine, mealy, white potato, with a deep rooting habit, which is probably the reason why it did so well under the conditions of this test. The subjoined yields are small, and this is accounted for by the nature of the soil (the same as described in the previous experiments), as well as by the moisture shortage accompanying the years in which the tests were made.

Assuming that there are 4,200 feet of row in an acre when the rows are 42 inches apart, lengths of 42 feet were dug in each variety, 42 feet being the one-hundredth part of an acre.

It would appear from the foregoing that the Irish Cobbler might be substituted for the Early Ohio with advantage.

GROWING SEED POTATOES UNDER A MULCH.

In addition to the foregoing, some work was done in testing the value of growing seed potatoes under a mulch. Only one variety, the Early Ohio, was used in this test. The result given below is the average of three different tests made in 1913, all of which showed decidedly larger yields when potatoes were grown under a litter mulch. The comparison here given is for returns per peck of seed planted. The seed was cut as nearly alike as possible. The reason for the yield not being given as per acre is because, to save labor in mulching, the potatoes grown in this way were planted in rows only 2 feet apart, and at half the ordinary distance apart in the row.

Unmulched potatoes, average yield of 3 separate	
pecks seed, per peck.....	84.5 lbs.
Mulched potatoes, average yield of 3 separate pecks	
seed, per peck.....	126.0 lbs.

From this it will be seen that the average yield when potatoes were mulched was nearly 50 per cent greater than in the case of unmulched. The returns are of marketable potatoes only. The proportion of unmarketable was larger in the case of the unmulched than in that of the mulched. How this would work out in a year more suitable for potato growing it is impossible to say. Probably the advantage of mulching might not be so apparent in seasons of more precipitation. The potatoes in these experiments were all dibbled in at a uniform depth of 4 inches. When the sprouts began to appear above ground the rows were clean cultivated in the case of those that were to be mulched, and the soil stirred with a garden fork to loosen it. The ground was then covered with straw to a depth of about 6 inches, and no

more work was done on them until harvest except to pull weeds. The unmulched potatoes in competition with them were cultivated four times during the season. The following year, 1914, seed that had been raised under a mulch as described was placed in competition with seed that was grown under ordinary conditions. Again, three lots of each were selected, and the averages of three tests are given below. The potatoes in both cases were grown under ordinary field conditions, the object being to determine what value mulching transmitted to the potatoes for seed purposes. The average of three different tests is given below in terms of one acre.

TABLE 16.—*Comparison of yield from seed grown under a mulch with that from seed grown in the ordinary way.*

Seed	Width of row	Length of row	Yield per row	Yield per acre marketable tubers
	<i>Inches</i>	<i>Feet</i>	<i>Pounds</i>	<i>Bushels</i>
Unmulched.....	42	42	29.25	48.70
Mulched.....	42	42	37.50	61.66

This shows a gain in the case of potatoes grown from mulched seed of nearly 13 bushels per acre. On account of the loss of seed this experiment was cut short at this point.

POTATO DISEASES AND PESTS.

In the Sand Hills section, while potato blight cannot be said to be unknown, the only diseases that have come under observation here which seriously affect the yields are scab and stem rot.

The formalin treatment for scab, which consists in soaking the seed for 2 hours in a solution containing one-half pint of commercial formalin diluted in 15 gallons of water, has been tested here with varying results.

Samples of seed infected with the disease have been treated, and every precaution taken to prevent reinfection, and yet the crop from such has been found infected. In other cases the formalin treatment of scabbed seed has been followed by the desired result. This would seem to point to a source of infection other than that of the seed. If no potato crop has previously been grown in the ground, the infection has probably been conveyed by manure. In any case it is better to disinfect the seed, as, unless the ground has been previously infected, doing so will in all likelihood prevent scab in the ensuing crop.

STEM ROT.

Stem rot is becoming increasingly common in the Sand Hills section. It can be detected, by slicing across the stem end of the tuber so as to leave the tuber stem in the center of the slice removed. If the disease is present it will be detected by the presence of a dark colored concentric ring of irregular shape. On paring deeper this ring usually becomes more distinct, and the tuber will be obviously unfit for human food. In combating this disease the seed should be disinfected with the same formalin solution recommended for scab; also, all seed showing discoloration when cut should be rejected and the knife used in cutting dipped in a strong formalin solution before using on other seed. It is further recommended that land that has grown a crop of potatoes affected either by scab or by stem rot should not be used again for the same crop till after the lapse of several years.

THE COLORADO BEETLE.

The potato bug or Colorado beetle is the only insect pest that has done much to damage potato crops at the Substation. This pest seems first to invade the crop on that side of it nearest to grass or to where weeds and other vegetation are growing, and if attended to before it has had time to spread, it can frequently be checked without having to spray the whole field. For spraying purposes, Paris green and arsenate of lead have been found about equally effective. When using the Paris green, some quicklime should be mixed in with it as it helps it to adhere, and also shows up on the leaves of the plants, thus serving to detect whether they are reasonably protected by the spraying.

A solution containing one pound of either Paris green or arsenate of lead to 100 gallons of water is about right. In very bright weather the plants will stand its being stronger. Arsenate of lead appears to be safer than the Paris green, as no vegetation injured by applications of that insecticide in reasonable strength has ever been observed here, while plants under shade have been quite seriously injured by applying the Paris green too strong. However, it is quite safe to use Paris green on potatoes if applied as prescribed above.

ROTATION OF CROPS IN THE SAND HILLS.

While at the Substation the land used in growing the main corn crop has not had any rotation of crops but has been kept under corn since being broken from sod five years ago, the yield and the fertility and texture of the soil have apparently been maintained and even improve This has been done by the

liberal application of barnyard manure put out on the ground during suitable winter weather or in early spring. This heavy dressing is possible on account of the greater moisture available, owing to the soil being subirrigated to some extent, thus assisting in speedier decomposition of the rougher parts of the manure. While this is true, it is probable that an occasional change to some small-grain crop would be good practice, were it not that the land adapted for a sure corn crop for the silo is limited.

It is reasonably certain that on the average Sand Hills homestead, by applying the manure produced on the land used for growing corn, and by occasionally rotating the corn with emmer or with rye, the soil on bench lands and dry valley bottoms could be kept without serious deterioration. But, where no manure is applied, or where the quantity supplied is insufficient, the deficiency cannot be made good by a rotation. This is particularly true if the rotation is one in which the main bulk of the crop is taken off the land, as would be the case in cutting small grain for hay. The soil would be gradually depleted of its fibrous organic matter.

To overcome these conditions, a system of farming recommended and practiced by some Sand Hills farmers, but which may appear wasteful and extravagant to owners of high-priced land where the precipitation is much greater and the soil more retentive of moisture may be worth description here. This is the system of allowing the half of the land used for corn growing to grow to weeds every second year, and raising the corn crop of one year on the land that was under weeds during the year previous.

The advocates of this method contend that it is conservative of the two principal desiderata of Sand Hills soil—organic matter or humus, and moisture, and that the Government, recognizing the peculiar requirements of Sand Hills farming, framed the Kinkaid Act, granting 640 acres instead of 160 acres, in order to meet the exigencies of the case. They further contend that the practice is no more wasteful of land space than the well-approved system of summer tillage or fallowing for wheat, while it is much superior in that, instead of using up organic matter as does the practice referred to, it is a means of increasing it.

The weeds, frequently of the sunflower variety, grow up thickly when the ground is given over to them, and in consequence they do not grow so large as to hamper future operations. In the spring following this weed crop, the corn is listed in, and the subsequent cultivation, which is best done with a sled cultivator, is relied on to work up the land, and roll the dead weeds into the lister furrows, where they are covered up with soil and quickly become decomposed, thus adding to the humus in the soil.

Under this system the land is never allowed to lie bare of vegetation, but is protected from the high winds that prevail in spring when, otherwise, under ordinary farming conditions, it is most likely to be found unprotected. The advantage which such a system offers, owing to the possibility which it affords of keeping the ground protected by vegetation at every stage of crop production, can perhaps only be appreciated by those who, from actual experience, have become familiar with the problem of soil-blowing on the lighter class of cultivated soil in the Sand Hills section, where it has quite frequently become the most important of all problems, upon the solution of which the homesteader's ability to support himself on his land depended.

The weeds, being left on the ground all winter, help in the conservation of moisture by arresting drifting snow and holding it on the land which is to bear the future corn crop. Furthermore, it is claimed for this system that the crop of the one alternate year will outyield those of two crops raised in successive years, and with little more than half the amount of labor, and this, whether it is attempted to raise corn every year on the same ground, or whether a small-grain rotation is used.

In addition, they maintain that, by alternating in this way with a "crop" that is turned under in its entirety, the soil is built up, whereas by following the other methods it soon becomes poorer, especially if little or no manure is applied. The system is described here for the consideration of the newcomer farmer, with the assurance that some of the most progressive and prosperous farmers in the Sand Hills not only recommend it but put it into practice.

TREE CULTURE IN THE SAND HILLS SECTION.

Only a few of the outstanding features and results of tree culture as carried out at the Substation will be given here. In all, about 2,000 trees have been planted at the Substation. This number is made up of cottonwoods, Norway poplars, box elders, honey locusts, black locusts, American elms, green ash, hardy catalpas, Russian olives, a few cedars, and about 500 bull or rock pines and jack pines.

PREPARING LAND FOR TREE PLANTING.

The planting was mostly done in the spring of 1911. As the land had only been broken from sod the previous year, then backset in the spring of 1911 just before planting, it is quite probable that the soil was not in first-class condition for tree planting. However, the desire to have a grove and windbreak

started as early as possible prevailed, and the work was begun as stated. The erection of a woven-wire fence on one side of the strip of land intended for the grove and the placing parallel to that at the distance of the width of the grove of a low bank of manure had an excellent effect in trapping snow during the winter of 1910-11, so that when planting time came in the spring the land was found much better stored with moisture than it would have been if left in its natural state. In view of subsequent experience it is realized that several mistakes were made at the beginning of this work. In the first place, in order to make a showing it was decided to plant cottonwoods, Norway poplars, and box elders, all of them fast growers, but also more or less short lived. These were mixed in with slower growing but usually longer lived trees, such as the pines, locusts, elms, ashes, etc., the idea being that as the latter began to occupy the ground the others would die or could be thinned. The trees were placed in rows 8 feet apart but only 4 feet apart along the rows, with the intention that when the less permanent trees were removed permanent trees 8 feet apart in every direction would be left.

PLANTING SO AS TO FACILITATE CULTIVATION.

It was soon discovered that the great enemy to tree growing was the amount of weeds that sprung up. Had the trees been 8 feet apart each way, it would have been a very much simpler matter to keep them clean without injuring their roots and stems. The cultivator could, in the case of the wider planting, have been run more freely across or at least angling to the rows as is done in cultivating checked corn. It was found that the roots of the cottonwoods and Norway poplars grow close to the surface, and for this reason it was impossible to cultivate so deeply as was otherwise desirable for the deeper rooting pines and deciduous trees. Later the difficulty was overcome by using a small Acme harrow to destroy the weeds.

The common disk is almost ideal for tree cultivation, as it can be used to better effect than any other implement for the purpose and with less effort on the part of the operator. Its roller-like action has no tearing up effect on the roots with which it may come into contact, such as have the shovels of the ordinary cultivator. Disk harrows can, of course, be got at any practical width, but where it is inconvenient to keep one small enough to cultivate between 8-foot wide rows, it would be well to plant the trees at distances apart that would admit of cultivation by the disk used for general farm work. It should also assist greatly in the cultivation and keeping of a grove or shelter belt free from

weeds if space were left at the end of the rows and on both sides of the grove, or belt, to permit turning the team, so that cultivation could be done crossways, as well as along the rows.

IMPORTANCE OF CLEAN CULTIVATION IN TREE GROWING.

Clean cultivation is important, as upon its being well done depends frequently the life of the trees in seasons of moisture scarcity. Neglect of cultivation allows the moisture to be depleted by transpiration thru the weeds that are sure to grow, as well as by excessive evaporation from the uncultivated surface of the soil.

Instead of the method adopted in this case, of mixing trees of distinctly different rates of growth, the better practice in tree growing would be to keep those quick-growing, short-lived, shallow-rooted trees in a place by themselves. In the spring of 1914 it was found that many of the cottonwoods and Norway poplars which had grown with great rapidity during the previous three years had died during the preceding fall or winter. For this there were probably several causes. The average precipitation during the years in which they had been growing was 17.30 inches instead of a normal 22.46. Their phenomenal growth had also something to do with it, as trees of such expansion must have made heavy drains upon the moisture in the soil, which, at a later stage, had become so exhausted as to be incapable of keeping up the supply. A certain amount of root pruning, the result of cultivation with shovel cultivators, had also more or less to do with causing their death.

IMPORTANT POINTS IN TREE CULTURE IN THE SAND HILLS.

In tree culture in the Sand Hills country, the following points are to be considered:

1. Select good fresh stock.
2. Firm planting is absolutely necessary. Trees will not do well if this is neglected.
3. Trees should be set far enough apart and be symmetrically spaced so that clean cultivation can be given without necessity for much hand hoeing.
4. Keep slow-growing trees separate from quick-growing, and shallow-rooting varieties separate from trees of a deep-rooting habit.
5. Do not mulch with manure. While doing so may at times save trees from drying out, the trees which survive without mulching are much more likely to be permanent. Mulched trees have the shallow-rooting habit.
6. Clean culture is much more to be depended upon than

artificial watering to preserve trees. Experiments proving this conclusively have been carried out here. The right kinds of trees have never suffered from want of moisture at this Substation if properly cultivated and kept clean.

7. If watering has to be resorted to, do it thoroly. One soaking that goes as deep or deeper than the deepest root is worth many sprinklings. Indeed, trees are frequently killed by constantly sprinkling them, especially when no after-cultivation is given.

8. Deciduous trees are better for being pruned before they are planted, or it can be done soon after. This, however, should not be severe, but sufficient to counterbalance the amount of root pruning which they have sustained in transplanting. Afterward, great care should be taken to see that pruning is so done as to avoid forks which, if allowed to develop, are sure to result later in broken limbs and disfigured trees.

In the Sand Hills almost all kinds of trees have the tendency to fork, but some, like the box elder and honey locust, are much more inclined to the habit than others. A low down branching habit makes it more difficult to cultivate trees. On the other hand, it has been found that small branches low down have the effect of protecting the tree trunk to some extent from the action of the sun.

VARIETIES OF TREES FOR THE SAND HILLS.

It is not presumed that all the trees which do well in the Sand Hills are mentioned here. What is aimed at is to mention the most suitable varieties that have been experimented with in Substation work here.

1. The Norway poplar has made the quickest growth of all planted, but, as indicated above, many trees of this variety died from drouth after the third year. All trees mentioned here have been grown on light sandy loam, with no moisture except what is derived directly from overhead.

2. Cottonwoods come next in rapidity of growth, but like the Norway poplar they have proved short lived under the conditions mentioned.

3. The box elder makes quick growth, and so far as yet shown at this Substation is more drouth resistant than either the poplars or the cottonwoods. Few box elders thus far have succumbed. Their greatest defects as shown here are their tendency to die back, and of all trees grown here they are the most difficult, perhaps, to keep in good shape. On more retentive soil the three species named are perhaps the best that could be planted for quick shelter. They are all comparatively free from injury by

borers, the worst of all insect pests with which trees here have to contend.

4. Of the slower-growing deciduous trees, the elm and the honey locust have undoubtedly done best, and the percentage of surviving trees is almost the same in the case of either. This amounts to about 60 per cent. The chief fault of the honey locust is its tendency to kill back, altho this has not resulted very frequently in spoiling the tree entirely as in the case of the catalpa. Some of the American elms planted here are among the most promising trees we have.

5. Green ash has not done well. Apparently it is a poor drouth resister and is subject to attacks from borers. Probably its inability to withstand drouth is the cause of borers attacking it. It has been observed that unthrifty trees are generally the first to be attacked. There are very few good specimens of ash at this Substation.

6. The Russian olive is scarcely suited for forest and shelter belt purposes. At the same time, it has given fair satisfaction here and does well if a good start can be given to it. For Sand Hills planting, good strong trees of this variety should be used. Small, weak trees are almost sure to fail. But with a good-sized healthy tree, well looked after during the first year, the chances of success are greater. It withstands drouth as well as any tree known here, and makes a good variety in lawn trees.

7. Of the jack and bull pines planted, not more than 25 per cent have survived. Some of the latter are fine specimens, and it is hoped that they can be kept alive. The jack pine is not so satisfactory. It kills back considerably, and is straggly and unsightly at best. The only other coniferous tree attempted to be grown here is the red cedar. It has been disappointing, showing weak growth, and each year trees that looked fairly well in fall are found beyond recovery when spring opens. In view of the fact that the red cedar is recognized as one of the most drouth resistant of trees, this failure was a surprise. It probably in this case was due more to exposure to high winds than to lack of moisture, as the few trees that survived occupied the most sheltered situations. From observations made here from time to time on these and other evergreens, such as pines, spruces, etc., it is believed that high, cold winds are more injurious than lack of moisture. In any case, the first symptoms of approaching failure have frequently been observed soon after exceptionally severe winter weather had been experienced.

8. The so-called *hardy* catalpa has not justified its name here. Out of 25 trees planted in 1911 only five are now alive, and these are not increasing in size, as they die back almost to the ground every winter.

9. Lawn trees and shrubs that have done well, in addition to the Russian olive already mentioned, are, first, and best of all, *Spirea Van Houttei*, which flourishes, giving a fine display of blossoms in early spring, and during the most of summer exhibiting a profusion of graceful, fernlike foliage. It requires but little care and is most worthy of a place in every lawn or garden. Next to it, perhaps, is the buffalo berry, which can be obtained wild in most places and stands transplanting very well. The Siberian pea tree has done well here, but is more susceptible to drouth than some of the others. The sumac also grows well, but its habit of growth is too suggestive of the persimmon to be pleasing to people familiar with that plant. Tartarian honeysuckle also does well but is an ungainly plant. Among the shrubs more recently tried out here, tamarisks and lilacs are the most promising.

Nursery orders for small weak trees should be avoided whenever possible, as trees of strong and somewhat mature growth do best in the Sand Hills. Trees that, to a certain extent, have begun to form their habit of growth in the nursery have given best satisfaction when planted out at the Substation.

ORCHARD AND SMALL FRUITS IN THE SAND HILLS.

The land surrounding the Substation, which has been already described as a light sandy loam on a subsoil of pure sand, is ill adapted for growing either orchard trees or small fruits, and in consequence very little work of this kind has been attempted. A few hardy apple, pear, cherry, and plum trees were set out in 1913, but, as was expected, the results have not been encouraging, the plum trees alone having made anything like a thrifty showing. In 1915 a few plums were found, but they dropped off shortly after setting, altho the moisture supply was abundant at the time, owing to the frequent seasonal rains. Strawberries are the only small fruit which have been experimented with at the Substation; but, altho it has been found possible—with the help of water from the pump and by keeping the plants mulched with litter and protected during winter—to raise a crop, the returns, at least in our opinion, are far from repaying the labor involved.

Whether the lower, subirrigated parts of the farm would grow these and other small fruits or the hardier varieties of orchard fruits has not been ascertained here, but it is almost certain that some of the small fruits could be handled successfully.

On the lower benches along the Niobrara and other rivers, when sheltered from the prevailing high winds, hardy varieties

of apple, pear, plum, and cherry do well, and are beginning to be commercially important, along with the fruit grown in the valley bottoms along the rivers where irrigation is practiced or where the ground is so subirrigated that the under surface water can be kept at a uniform level by drainage. Under such conditions it is possible to raise abundant crops of apples, pears, crab apples, cherries, and plums, as well as an abundance of small fruits, in average years.

Among apples the Ben Davis, Gano, Wealthy, McIntosh, Charlamoff, Duchess of Oldenburg, Wallbridge, Yellow Transparent, the Northwestern Greening, and the Whitney crab do well; as do also the Duchess and one or two other varieties of pears; and the Compass, Sapa, and Opata cherries, hybrids between the sand cherry and the plum, are adapted to Sand Hills conditions, even on dry bench lands being found to do well. Red and white currants flourish profusely in some of the sheltered valley bottoms under cultivation, as do the gooseberry, dew-berry, raspberry, blackberry, and strawberry. The most prominent wild fruits are the sand cherry, which grows on sandy uplands and along the river and hill canyons, the sour cherry, grape, and plum flourish, the last in great profusion.

THE KITCHEN GARDEN IN THE SAND HILLS.

Perhaps no other section of the Middle West surpasses that of the Sand Hills in the variety and quality of the vegetables grown in it. This is true, particularly of the sheltered bench lands wherever irrigation can be applied, as well as of the subirrigated valley bottoms.

It is unnecessary to mention here all the varieties raised, as the list of them would be co-extensive with that of the Middle West seedsman's catalog; but asparagus, cabbages, celery, onions, tomatoes, and all varieties of the cucurbit family are grown with great success.

On light, dry soil such as surrounds the Substation buildings already described in connection with alfalfa and other experiments, unless a supply of water from the windmill or tank is available there is some uncertainty in the attempt to grow vegetables.

From the nature of the crops grown, the soil humus in a garden composed of such light dry soil is quickly depleted, and it is highly necessary that the supply should be replenished by the careful application of well-rotted barnyard manure in such quantities as can be well assimilated by the ground. This should be put on before the land is plowed in the fall—as all garden land

should be, after raking off and destroying old vines and other garden rubbish. The fall plowing and removal of infested rubbish helps greatly in keeping the garden free from the various garden pests. The plowing in of well-rotted manure in fall, besides adding to the direct fertility of the soil, helps to make it more retentive of winter moisture, and both combined have the effect either of retaining heat in the soil during winter or of absorbing it more freely in spring than land not so treated. This has the effect of making the garden earlier than it would be were the manuring and plowing left over till spring. With these precautions, and planting as early as the state of the ground will permit, the following vegetables have been grown successfully at the Substation every year without artificial watering, with the exception of the abnormally dry season of 1912 when most vegetables failed except such as could be watered. Beans, beets, early cabbage, corn, carrots, cucumber, watermelons, muskmelons, squashes, early peas, early potatoes, radishes, turnips, and tomatoes. All hardy varieties should be got into the ground as early as possible, and in the case of the less hardy it is better to take some chances by putting them in early, than to wait till later, as the surface soil in which the smaller seeds must develop is very apt to become dry as soon as the weather begins to warm up, making it difficult to get good seed germination.

USE OF THE FEET IN SOWING GARDEN VEGETABLE SEEDS.

In sowing vegetable seeds in dry Sand Hills land gardening, probably more seed is wasted by putting it into too loose ground than from any other cause. Especially is this the case with people who have recently come into this country from more moist or heavier soiled regions where firming the ground around the seed is not so necessary. Small seeds, as most garden seeds are, should be placed at the bottom of a very shallow furrow and the soil pressed down firmly upon and around them. For this purpose nothing surpasses the foot, as it is self-registering, so to speak, and anyone with experience can tell to a nicety by the feel of the ground under it, just how much pressure is necessary for the desired result. Few people realize how important this one simple point in gardening practice is, especially in a dry climate and on porous soil, or understand the vast loss of seed, not to speak of time and effort in preparing ground and sowing, that is caused by its neglect. Even if the seed does grow, it will come up much faster on land that has been well firmed after seeding. Some experiments along this line have been conducted at the Substation. Corn and navy beans were planted with the ordinary

hand corn planter. Alternate rows of either were then gone over with the heel of the foot and well pressed down, and the soil firmed. In the case of the beans the percentage of seed that germinated in loose soil was 82, while in the pressed rows there was a stand of 98 per cent. The corn in uncompressed soil showed a germination of 87, while in the soil receiving the heel treatment after planting, the percentage was 96. The compressed corn showed up three days in advance of the uncompressed. The beans were all up before any record of germination was obtained, but the compressed rows showed a marked superiority over those in the rows that had not been firmed. No experiments were carried out with smaller seeds, but firming of the soil is still more important in their case than it is in that of such large seeds as corn and navy beans, for the reason that they are planted at less depths and therefore in looser and drier soil.

LAWNS.

Second only to that obtained from a grove of trees is the comfort and satisfaction derived from a well-kept lawn adjoining the dwelling house, whether the situation be on the farm or in the town.

Altho in the Sand Hills the farmhouse is usually placed as close as possible to the more fertile and productive land, yet, because of drainage and other considerations, the site usually chosen is on elevated or sloping land, which generally means that the surrounding soil is of a light, dry character, where it will take considerable care and frequent attention to establish and maintain a grass sod. The towns and villages in the Sand Hills are also frequently situated on land of a light or sandy nature, and as no residence in these is considered complete without its patch of blue grass, the subject of lawn making and maintenance is of sufficient importance to justify notice here.

At the Substation a blue-grass lawn of more than one-third acre extent was laid down over four years ago, and has been kept in good condition since, without excessive expenditure of time and water. In order to reduce the work of keeping this lawn in thrifty condition, great care was taken in laying it down. The original soil being of poor quality, it was considered better to enrich it by adding sod or turf from another part of the prairie, and an abundance of old well-decomposed manure.

The ground in front of the house, which was in sod where it had not been cut up by wagon wheels, was carefully cleared of all building debris, such as sand, shingles, ends of plank, bricks, and stones, all of which are quite frequently incorporated in the lawn

soil, especially in cities and towns, where they are often the cause of future trouble and disappointment. The sod was then thoroly disked till it resembled plowed land, when it was plowed with a stirring plow and disked again. About thirty loads of old manure were then applied and mixed in with the soil, after which an equal number of two-horse loads of sod cut from another part of the prairie was added and harrowed till it was well pulverized. It was again turned with the stirring plow and left in that state till spring, when it was well dragged and smoothed down with a leveler made of two 16-foot planks joined by cross planks 4 feet in length, which was dragged over it to plane the ground and give it a uniform surface, as is done when preparing land for irrigation. This smoothed surface was then dragged in order to furrow the soil to receive the seed, which, after being sown with a hand seeder, was covered with a large garden rake. Then the soil was firmed by putting a planker drawn by two horses over it, in the absence of a roller, which would have done still better work had it been available. The seeding was done as early as the state of the ground would permit. The weather turning dry and windy, the surface was protected by a dressing of rough prairie hay and litter, which held the soil in place, and also prevented excessive evaporation, and the whole was sprinkled from the hose as frequently as it was found necessary to do so.

The seed, which was sown at the rate of 6 quarts per 450 square feet, or 3 bushels per acre, was a mixture of Kentucky blue grass, Italian rye grass, and white clover, in the proportion of 4 parts by weight of blue grass to 2 of Italian rye grass and 1 of white clover. The Italian grass and clover were for the purpose of raising a nurse crop. The Italian grass grew rankly, shading the ground, but was killed out at the beginning of winter by frost, as was expected. Its dead leaves were left in clumps protecting the blue grass, which had come up more slowly beneath them.

This lawn has received two top dressings of 4 or 5 two-horse loads of well-rotted manure since it was laid down, this being done at the beginning of winter. Top dressing a lawn occasionally is very beneficial especially in the Sand Hills country. Besides enriching the soil, the dressing fills up the pits that are excavated around the grass clumps by the action of high wind on a sandy soil.

Whenever it is considered advisable to water it, the lawn is well soaked instead of being sprinkled, as only sprinkling the surface favors a shallow-rooting habit. No attempt is made to keep this lawn green during the hottest part of the season, as to do so would incur the use of a large quantity of water. It is allowed to get brown but not burnt, and it is found that as soon as water

is applied, or when rain comes, or when the weather turns cooler the grass quickly revives. No reseeding has been done since the lawn was established, and the grass is thicker now than at any previous time.

The grass is cut with a two-horse mower, but never close down to the ground, as it has been found that out in the open, close cutting such as is done with the hand lawn mower is injurious to the grass. Under trees or where lawns are frequently and abundantly sprinkled, close cutting may not show such injurious effects. The grass is raked off soon after mowing, all except the last fall cutting, as the dried grass is apt to give the lawn a burnt up appearance unless removed.



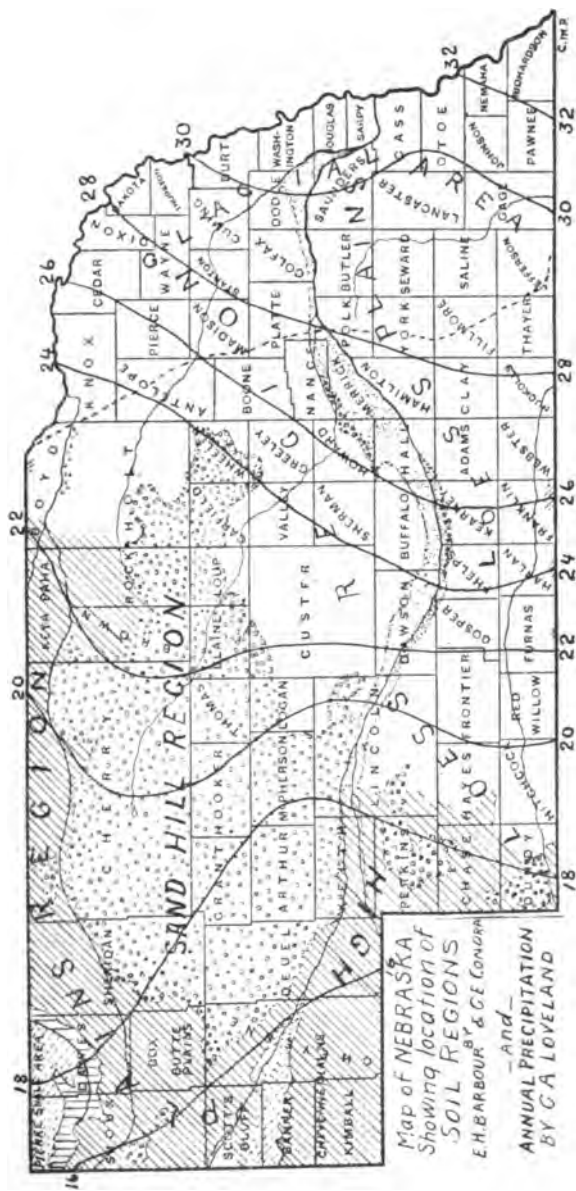
Fig. 7.—Concrete block dairy stable and silo at the Substation.

ESTABLISHMENT OF A DAIRY HERD.

It having from the beginning been the purpose of the Board of Regents of the University to establish a dairy herd at the Valentine Substation, a dairy barn of 30-cow capacity, also a silo of 100-ton capacity and other equipment for dairying purposes, were included in the permanent improvements. The cow barn was

finished in 1913, and at the beginning of 1914 dairying operations were begun.

The herd is composed of a number of pure-bred Holstein cows and a larger number of the common milch cows of the district, headed by a pure-bred Holstein bull. As the results obtained will probably later form the subject of a bulletin, it is unnecessary to refer further to them at this time.



5400

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THE UNIVERSITY OF NEBRASKA.
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OF
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VOLUME XXIX, ARTICLE I.

FARM MANAGEMENT STUDIES IN
EASTERN NEBRASKA

BY H. C. FILLEY.

DISTRIBUTED OCTOBER 15, 1916.



Economic use of man labor.

LINCOLN, NEBRASKA
U. S. A.



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SUMMARY.

1. In figuring farm profits, the farm must be placed upon the same basis as any other business.

2. The 80-acre grain and stock farm of eastern Nebraska does not utilize man, horse, or machine labor as efficiently as do farms of a larger size.

3. The family farm which provides work for approximately two men or the equivalent, seems to be the most profitable. On the farms surveyed, approximately half of the work, aside from that done by the operator, was performed by boys under 21.

4. The best paying farms found in this survey had crop yields from 15 to 30 per cent better than the average of all farms, while of the farms whose yields were as much as 15 per cent below the average of their community, few gave satisfactory returns.

5. The most profitable farms included in this survey sold two or three major products and from two to four minor products. Those selling but one or two products were not profitable as they did not furnish productive labor for a large enough part of the year.

6. If 5 per cent interest is allowed upon all capital invested by the operator, owned farms returned an average labor income of \$203 and tenant farms an average of \$806 to the operator.

7. The better showing made by the tenant farms is largely accounted for by the fact that they returned to the landlord only 3.5 per cent interest upon the land valuation, while the owner-operator is charged 5 per cent upon his valuation. The low rate of return is due primarily to the security of the investment.

8. Owned farms in Richardson county contributed \$509, and tenant farms \$405 toward the farmers' living, in addition to the "labor income". This is somewhat above the average of farms covered by the survey.

9. Placed upon the same basis as the city wage earner, with interest upon land figured at the landlord's rate of return, the average farmer of eastern Nebraska receives between \$1,000 and \$1,200 per year for his labor and management.

FARM MANAGEMENT STUDIES IN EASTERN NEBRASKA

H. C. FILLEY.

Within the last few years the impression has become general, particularly among business and professional men, that the farmer is making a great deal of money, and that he is enjoying more than his share of the prosperity of the country. Probably the most potent cause for this opinion has been the rise in the cost of living. The consumer unquestionably pays much more for nearly all agricultural products than he did in the middle nineties, and the farmer is receiving more for his products now than he did during the depression which followed the panic of 1893.

The decade from 1890 to 1899 is probably the poorest time that can be selected as a basis with which to compare present prices, because conditions were not normal during the greater part of the period. The ease with which the level prairies of the middle West could be broken up and prepared for cultivation, the invention of many labor-saving farm machines, the use of which more than doubled a man's productive capacity, the free homestead act, and the large number of immigrants from northern Europe who were even more anxious than the Americans to accept the gift of a farm from a generous Government—all these causes united in bringing about the greatest over-production of agricultural products that the world has ever known. In the midst of this over-production came the panic of 1893, followed by a greatly lessened consumption during the ensuing financial depression. Dire necessity and not cost of production fixed the price for agricultural products. The farmer was too absorbed in providing the necessities of life to consider cost of production, interest on investment, or labor income.

In discussing the trend of prices in recent years, the consumer has sometimes neglected to ascertain how large a part of the increased price which he pays ever finds its way to the pockets of the agricultural producer. The farmer pays a higher price for labor and practically all other commodities which he purchases, than was the standard of twenty years ago. Before reaching any definite conclusion regarding farm profits all these factors must be considered.

The rapid rise in land values during the last fifteen years has strengthened the impression regarding the large volume of the farmer's profits. It is certainly true that the owner of land is worth more today than twenty years ago, and because of that we say that he has prospered. The rise in value has neither decreased his cost of production nor increased the productivity of his land. We must remember that the word "farmer" is not a synonym for "farm owner" as about 40 per cent of the farms in Nebraska are operated by tenants.

The rise in the value of farm products has been accompanied by an almost automatic increase in the rent obtained from land. As rents have increased, lands have risen in value, and the man who would buy to avoid paying rent finds that he must invest a much larger sum than was formerly necessary. Increased land values apparently mean increased prosperity for those who sell or rent their lands, but require larger outlays for buyers of land or for tenants. If rent, or interest on capital invested in land, is considered a part of the cost of producing crops, then a rise in land values increases cost of production for the farmer, whether he is a tenant or an owner.

In order to find out whether the farmers as a whole are making a profit on their business, we must judge them not by comparing the crop prices and land values of today with the prices of twenty years ago but by using the same standards that are used in judging the prosperity of any other business. In other words, what interest does the farmer receive on the capital which he has invested in land and equipment, and what wages does the farm pay for the labor of the farmer and his family?

In practically all communities we find some diversity in types of farming, in methods of work, in management employed, and in the prosperity of the farmers themselves. Some men accumulate rapidly while near neighbors who apparently work just as hard fail to get ahead. This difference cannot be attributed entirely to soil, climate, or chance; a part of it must be due to the efficiency of the farmer, to his skill in combining the three essentials of production,—land, labor, and capital.

All the great business organizations of today are planned with this matter of efficiency uppermost in mind. Many of them have been studied by efficiency experts and organized so that labor and equipment are so well utilized that the greatest economy of production is brought about. In order to produce most economically it becomes necessary to know first what the capacity of a business is, and then keep it running to its full capacity, if possible. If a flour mill, for example, with a capacity of 100 barrels a day, is made to produce an average of only 40 barrels a

day, a loss results because the labor and capital are not being used to the best advantage. The mill owner, other things being equal, cannot manufacture flour as cheaply or compete successfully with the mill owner who utilizes the full capacity of his plant.

Exactly the same principle holds true in farming. If labor and equipment are not made to serve to their full capacity throughout the year, the output of the farm will be greatly lowered and the profits correspondingly decreased. Every farmer should study his business with the idea of determining its capacity, and it should then be his purpose to keep that business running to the capacity which earns the largest net profits.

The best method of making an accurate study of the farm practices and business principles adapted to any given community is by a farm management survey. By visiting a large number of farms, and learning how the more successful ones differ from the less successful, we are able to determine the controlling factors of efficient management in that locality.

In general, the results of this survey verify the results of surveys made in other states. The principles of farm management which should govern farm practice in that part of Nebraska which lies in the corn belt are very evidently the same as have been found applicable in states farther east. We may infer that, while type of farming will vary with markets and natural factors, the fundamental principles of good farm management are widely applicable.

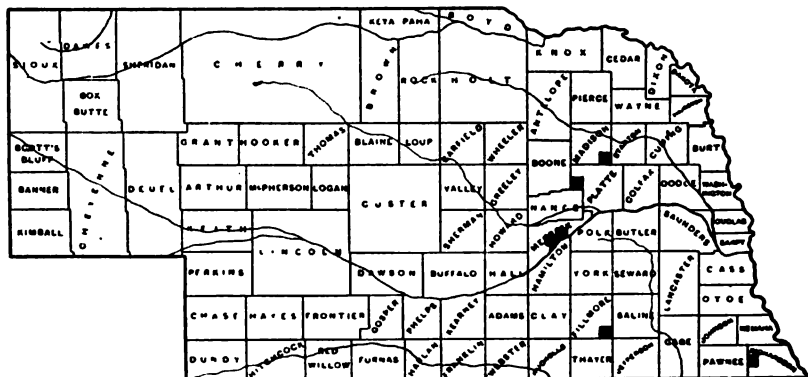
AREAS STUDIED.

The results given in this bulletin are nearly all from four areas surveyed in eastern Nebraska in the counties of Madison, Platte, Merrick, and Richardson. They represent fairly well the conditions for that part of the state which lies in the corn belt. Some data are also presented from a survey taken in Fillmore county for the crop year 1913, when the corn crop was an almost total failure. This shows subnormal conditions. A very few tables are presented which contain data from four hundred farms for 1914, a year of average yields and of unusually high prices.

The Platte County records are for 1911; Merrick County, 1912; Madison County, 1913; and Richardson County, 1914. While the Madison county records are doubtless slightly below normal, the Richardson County records are probably enough above normal to offset any lowering of the average.

Altho the soils of the areas studied are not uniform, there is apparently little variation in their average fertility, compared

one with another. All the areas lie east of the 27-inch rainfall line, and in normal seasons have ample moisture for ordinary crop production.



Areas studied.

METHOD OF STUDY.

The farms in the different areas were visited personally, and the results obtained direct from the operator. The majority of the farmers kept only meagre accounts; but practically all had very definite recollection of the products sold, the price received, and the expenses paid. On practically all Nebraska farms, grain and live stock are sold in large quantities and but few sales made during the year. It is a simple matter to check the sales of wheat with the wheat produced, and to obtain the local price of wheat for each week of the year. The farmer cannot miss either the quantity sold or price received by any considerable amount without the error showing in the record. The majority of men know the exact number of bushels threshed, the amount saved for seed, the amount sold and the exact price received per bushel. Other grains and live stock are checked in a similar way.

The expense account may seem at first thought to admit of considerable error, but it must be remembered that household and personal expense does not enter into the survey. These are the expenses that one would forget and have difficulty in estimating. All ordinary items of farm expense are listed on the field blank. Such items as threshing readily check with the amount of grain produced. The amounts paid for labor, feed, seeds, twine, taxes, insurance, and other similar expenses are usually remembered.

Data from each area surveyed were tabulated separately and the results found to be in general accord with the results obtained when all areas are tabulated together. Because of this it has seemed unnecessary to present tables for the individual areas.

This does not imply that the areas are the same in all respects. In Richardson County, for example, because of a slight difference in rainfall, soil, contour, and other natural factors, we find more fruit than in the other areas. According to the 1910 census, there are more than twice as many farms of less than 50 acres in Richardson County as in any of the other counties mentioned in this bulletin. These small farms are quite largely fruit and truck farms. Since the survey in that County includes only one farm of less than 50 acres and none which sold any considerable amount of fruit, this slight difference does not affect any of the conclusions reached.

DEFINITIONS.

A few farm management terms have come into general use only among students of this subject, and some common words which have a variety of meanings are here used in a particular sense. The following definitions must be thoroly understood before this report can be read intelligently:

Farm Capital.—The farm capital is the total value (at the beginning of the year) of all real estate, machinery, live stock, feed and supplies, and cash necessary to carry on the farm business. It includes the value of the farmhouse but not the household furnishings. Money owed by the farmer is not subtracted, and property owned by him outside of that used in the farm business is not added.

Gross Income.—The gross income of the farm is the sum of all farm receipts including produce paid for "in trade." It includes nothing from outside the farm such as interest on bank stock or money loaned. In a few instances where the meaning is plainly shown by the context it is referred to simply as the "income."

Net Income or Farm Income.—The net income or farm income is the difference between the gross income and the farm expenses.

Expenses.—The farm expenses include all business expenses of operating the farm. Depreciation on buildings and machinery, and any decrease in feed inventory are included in the expenses. The cost of the board furnished hired labor is considered a part of the expense of the labor. Unpaid family labor used in any of the farm operations is also considered as an expense. Household and personal expenses are not included.

Labor Income.—The business man of the city usually considers his own salary as a part of the expense of doing business, and his net income as his profit. This method is necessarily followed by corporations where everyone who works for the company receives a salary, and many of the stockholders do no part of the work. The business man of the farm does not pay himself a fixed salary, and his net income includes both his wages and the interest on his investment.

In dividing the net income of the farm between wages and capital, we can either allow the farmer a fixed wage and consider the remainder as profit on the capital, or set a definite interest rate for the wages of capital, and consider the remainder as the labor income or profit of the farmer. For many reasons the latter method is better. In this bulletin, interest is figured at 5 per cent except where otherwise stated. In addition to the labor income, the operator received a house in which to live, and whatever fruit, vegetables, milk, butter, eggs, meat, and fuel that the farm furnished toward the family living.¹

Farm Owner.—The man who operates his own farm is called the farm owner.

Part Owner.—The part owner is a farm owner who rents additional land.

Landlord.—The landlord is the owner of land farmed by a tenant.

Tenant.—The tenant is the person who operates rented land.

Animal Unit.—An animal unit is one full-grown horse or cow, or an amount of other live stock requiring the feed of a horse or cow, as: 2 colts, 2 calves, 5 hogs, 10 pigs, 7 sheep, or 100 chickens. Altho the feed given various classes of live stock varies widely on different farms, the above rough approximation suffices for the purpose for which it is here used. On the average Nebraska farm, a work horse receives more feed than a cow, while on the intensive dairy farm, a cow is apt to receive more feed than a horse.

Productive Animal Unit.—A productive animal unit increases the revenue of the farm either by its own growth; by producing young; or by some livestock product. Colts, calves, hogs, chickens, and milch cows are productive animal units, but work horses are not.

SIZE OF BUSINESS.

In comparing farms upon the basis of the size of the farm business, several different units of measure may be used, among which the most common are: total farm area, crop acres, total

¹Table 19 gives an example of the method employed in figuring labor income.

capital, and gross income. Whichever measurement is applied the same general results hold true of the farms included in this survey.

In a majority of the tables upon size of business, the farms are grouped in classes according to the area in acres. This is satisfactory since nearly all farms are of the same general type,—mixed stock and grain farms. No data has been collected from farms where the sale of fruit and garden truck provides any considerable part of the farm income. Since a truck farm of 20 acres may provide as much opportunity for income-producing labor as a stock and grain farm of 200 acres, it would be manifestly unfair to base any comparison of the size of the business of these two types of farming upon the comparative area in acres. No data are presented in this bulletin from which inferences can be drawn either directly or indirectly concerning the area or profit of the truck farm.

TABLE 1.—*Relation Between Farm Area and Labor Income in Eastern Nebraska.*

Area of farms (in acres)	Average area per farm	Number of farms averaged	Average labor income per farm
40—100.....	80	20	\$122
101—150.....	124	27	355
151—200.....	167	68	323
201—250.....	237	33	684
251—320.....	292	27	444
Over 320.....	423	20	324
All farms.....	207.5	195	\$385

Neither the small nor the very large farm gave as good returns as those of intermediate size, the farms of from 201 to 250 acres averaging considerably better than any other group. The group of farms of from 40 to 100 acres, nearly all of which are 80-acre farms, returned a labor income of about one-third the wages paid a married farm hand where a house and other perquisites are furnished. The farm doubtless furnishes a better home and contributes more toward the family living than the hired man receives, yet the income seems to be a poor return for the labor expended.

WHY THE 80-ACRE FARM SELDOM PAYS ADEQUATE RETURNS.

A comparison of the organization of the small farm with those of larger areas shows wherein it is inefficient.

TABLE 2.—*Relation Between Size of Farm and Distribution of Capital.*

Area of farms (in acres)	Total capital	Value land (not includ- ing buildings)	Value house	Value other buildings	Value live stock
40—100	\$10,969	\$7,648	\$1,103	\$656	\$921
101—150	16,619	12,733	1,041	898	1,276
151—200	21,008	19,290	905	813	1,437
201—250	30,088	27,987	1,027	974	2,116
251—320	38,076	31,468	1,216	1,781	2,274
Over 320	53,921	45,965	1,400	1,465	3,346
Average	\$26,543	\$21,727	\$1,053	\$1,036	\$1,793

There is but little difference in the value of real estate per acre, altho the small farm has nearly as good a house as the larger farm. The small farm provides shelter for but little live stock in addition to the work horses.

A study of capital distribution by per cents furnishes a more accurate basis for comparison than does the preceding table.

TABLE 3.—*Relation Between Size of Farm and Distribution of Capital (by per cent).*

Area of farms (in acres)	Per cent of total capital invested in					
	Land (not including buildings)	House	Other buildings	Live stock	Machin- ery	Feed, etc.
40—100	69.9	10.1	6.0	8.4	2.5	3.1
101—150	76.3	6.3	5.4	7.8	1.8	2.4
151—200	80.3	4.3	3.9	6.8	1.9	2.8
201—250	81.5	3.4	3.2	7.0	1.7	3.2
251—320	82.7	3.2	4.7	6.0	1.3	2.1
Over 320	85.3	2.6	2.7	6.2	1.3	1.9
Average	81.5	3.9	3.8	6.7	1.5	2.6

The per cent of investment in land increases with size of farm but the per cent of investment in house and buildings decreases. The per cent of capital invested in live stock is largest on the small farms, but if we except work horses, it is smallest on the small farms.

Because it is necessary for the corn belt farmer of today to use four-horse machinery in order to utilize his own labor efficiently,

the horse does less work on the 80-acre farm than on those of a larger area. This fact is clearly shown in Table 4.

TABLE 4.—*Relation Between Size of Farm and Efficiency of Horse Labor.*

Area of farms (in acres)	Average number of crop acres per farm	Average number of work horses per farm	Average number of crop acres per work horse
40—100.....	63	3.8	16.9
101—150.....	100	5	20.5
151—200.....	130	5.8	24.3
201—250.....	180	7.1	26.7
251—320.....	233	8.5	29
Over 320.....	293	9.6	32.1
Average of all.....	153	6.46	24.7

The horse which cares for only 17 crop acres costs the owner almost as much each year as the horse that cares for 30 crop acres. Interest on investment, depreciation, taxes, and cost of shelter are not affected by the number of days which the horse works each year. Care and feed ordinarily vary with the amount of work done, but even the idle horse must have some care and a maintenance ration.

Altho the cost of machine labor is much less than the cost of horse labor, it is an item that must be considered. Interest and other costs continue night and day whether the machine works or stands in the shed.

TABLE 5.—*Relation Between Size of Farm and Efficiency of Machinery.*

Area of farms (in acres)	Capital invested in machinery per farm	Per cent of total capital invested in machinery	Capital invested in machinery	
			Per horse	Per crop acre
40—100.....	\$273	2.5	\$72	\$4.35
101—150.....	299	1.8	60	2.99
151—200.....	411	1.9	70	2.32
201—250.....	516	1.7	72	2.87
251—320.....	495	1.3	60	2.12
Over 320.....	692	1.3	72	2.36

The 80-acre farm ties up an unduly high per cent of its capital in machinery, and as a result has a larger investment per crop

acre. The larger farm has a fuller equipment at a lower proportionate cost. After we reach farms of 150 acres there is less difference in machine cost per acre because duplication begins. The larger farms also often have machines, such as a corn binder and ensilage cutter, which the small farmer cannot afford.

Man labor is ordinarily more expensive than horse or machine labor. If man labor is being employed efficiently, a farm will ordinarily show a good labor income. If a man uses two-horse machinery when his neighbor uses four-horse, and if his system of farming fails to provide regular productive labor thruout the year, he can hardly expect to have a large net profit. Table 6 illustrates the handicap under which the man works who farms 80 acres of Nebraska land.

TABLE 6.—*Relation Between Size of Farm and Efficiency of Man Labor.*

Area of farms (in acres)	Average labor income per farm	Average number of men per farm	Average number of crop acres per man	Productive animal units per man
40—100.....	\$122	1.11	58.5	6.7
101—150.....	355	1.14	90	9.5
151—200.....	322	1.38	101.9	10.9
201—250.....	684	1.9	101.2	13.5
251—320.....	445	2.14	114	11.9
Over 320.....	324	2.61	113.5	16.6
Average (195 farms) .	\$385	1.54	98.5	11.4

The man on the small farm cares for fewer acres of crops, and also cares for fewer head of live stock than the man on a larger farm. His labor is utilized less efficiently. There is a great deal of farm work, haying, for example, where one man works at a disadvantage. On the size of farm that gave the best labor income, 201 to 250 acres, two men are employed practically all of the time. They are able to use their own labor and to utilize horse and machine labor about as well as the men who farm a larger area.

CROP YIELDS AND DIVERSITY.

It has been popularly supposed that crop yields are better on small than on large farms as a result of more intensive tillage. Yields upon the farms covered by this survey do not bear out the theory of high yields on the small farms due to better tillage. Yield seems to be almost independent of size of farm, the groups of large farms showing up slightly better than the smaller farms.

TABLE 7.—*Relation Between Size of Farm, Crop Yields, and Diversity of Business.*

Area of farms (in acres)	Crop index ¹	Diversity index ²
40—100.....	101	2.9
101—150.....	97.5	3.3
151—200.....	97.3	3.77
201—250.....	104.7	4.02
251—320.....	103.3	3.6
Over 320.....	103.8	3.6
Average of 195 farms.....	100	3.54

¹The crop index expresses on a percentage basis the crop yields of an individual farm compared with the average yields of the farms surveyed. All crops and their proportionate areas are considered.

The method commonly employed in finding the crop index of a given farm is to divide the quantity of each field crop produced on the farm by the average yield of that crop per acre on all the farms. The quotients obtained from these divisions are added and their sum divided by the field area of the farm.

The following example illustrates the method:

Assume that in the survey area, the average yields per acre are found to be as follows: Corn, 28 bushels; wheat, 24 bushels; oats, 35 bushels; and alfalfa, 2 tons. A's farm for which the crop index is desired has the following acreage and production of these leading crops.

Crop	Acreage	Yield	Production
Corn.....	40	32	1,280 bu.
Wheat.....	80	20	1,600 bu.
Oats.....	10	40	400 bu.
Alfalfa.....	20	2½	50 T.
Total acreage.....	150		

By dividing the number of bushels of each crop produced by the average yield of that crop for the region, the number of acres required to produce the crop on the average farm is obtained.

Crop	Production on A's farm	Average yield per acre for the region	Average acreage required to produce A's crop
Corn.....	1,280 bu.	28 bu.	43
Wheat.....	1,600 bu.	24 bu.	67
Oats.....	400 bu.	35 bu.	11
Alfalfa.....	50 T.	2 T.	25
Average acreage required to produce A's crop.....			146

Dividing 146, the average number of acres required in this region to produce A's crop, by 150, the number of acres required by A, gives 97.3, the crop index.

²The diversity index is a figure which expresses the number of different farm enterprises in terms of enterprises of equal size. It is determined as follows: The total receipts are divided by the total number of enterprises or sources of income. Each enterprise which contributes more to the gross income than the average of all is counted as 1. All that contribute less than the average are added and divided by the average. This quotient is then added to those major enterprises which are counted as one each.

For example a farm has the following receipts:

Hogs.....	\$625
Cattle (including cream sold).....	415
Poultry (chickens and eggs).....	124
Wheat.....	513
Corn.....	180
Oats.....	87

Gross income.....\$1,944
 $\$1,944 \div 6 = 324$ average of all

The man who farms a quarter section or over usually sells a greater variety of products than the man who farms only 80 acres. His labor is utilized efficiently because it is distributed thruout the year. The farms of from 201 to 250 acres have the greatest diversity of products as well as the best labor income. Most of them marketed two or three major products and about the same number of minor products.

CAPITAL.

One of the standards most commonly used in measuring the size of a business is the amount of capital invested. This standard is quite as applicable to the farm as to the city business.

The average capital of the 195 farms surveyed was \$26,646. Only 10 farms had a capital of less than \$10,000, while 40 farms had a capital of more than \$35,000. As the farms increased in size, the capitalization per acre increased, being considerably higher on the large than on the small farms. This is shown in Table 8.

TABLE 8.—*Relation Between Capital and Farm Area.*

Capital per farm	Number of farms	Average capital per farm	Average area per farm in acres	Average capitalization per acre
Under \$10,000.....	10	\$7,633	81	\$94
\$10,000—\$18,000.....	45	14,791	125	118
18,000— 25,000.....	50	20,905	166	126
25,000— 35,000.....	50	29,594	233	127
Over \$35,000.....	40	47,819	356	134
Average (195 farms)...	..	\$26,646	207.7	\$128

When the farms divided upon the basis of capitalization are compared with the labor income, practically the same relationship is found to exist as when they are divided upon area in acres.

Hogs, cattle, and wheat having greater receipts than \$324 are major products and each adds 1 to diversity index.

$$\$124 + \$180 + \$87 = \$391$$

$$\$391 \div 324 = 1.2$$

Hogs 1, + cattle 1, + wheat 1, + miscellaneous 1.2 = 4.2 diversity index.

TABLE 9.—*Relation Between Capital per Farm and Other Financial Factors.*

Capital per farm	Receipts per farm	Expenses per farm	Farm income	Interest on capital at 5 per cent	Labor income
Under \$10,000	\$830	\$234	\$596	\$382	\$214
\$10,000—\$18,000	1,455	443	1,012	740	272
18,000—25,000	1,980	582	1,398	1,046	352
25,000—35,000	3,023	1,036	1,987	1,480	507
Over \$35,000	4,420	1,630	2,790	2,391	399
Average	\$2,583	\$866	\$1,717	\$1,332	\$385

The men whose capital was less than \$10,000 had average receipts of only \$830. After paying expenses and allowing 5 per cent interest upon the investment these men had a labor income of but \$214. In order to make a good labor income upon a farm of this size, the receipts must be increased. As the capitalization increased, the gross receipts increased faster than the expenses. This resulted in the farmer receiving a larger farm income and, until \$35,000 capital was reached, a larger labor income.

These figures do not look encouraging to the man with small capital who would buy land. They indicate that he should either rent land or engage in a type of farming requiring a smaller land area than grain and stock farms of the corn belt.

INFLUENCE OF CROP YIELDS UPON FARM PROFITS.

The effect which the general failure of any important crop has upon the prosperity of a community is so striking that it is always noticed. Records taken where the 1913 corn crop failed show that two-thirds of the farms whose crop index fell below 85 were operated at a loss, and only 3 per cent showed more than \$500 profit. The farms where the acreage of corn was small and crop index consequently higher nearly all showed a profit.

The man whose crop yields in a normal year fall very far below the average of his community has little chance of receiving a satisfactory labor income. The following table shows the characteristic effect of crop yields upon labor income.

TABLE 10.—*Relation Between Crop Index and Labor Income.*

Crop index	Number of farms	Average crop index	Labor income	Productive animal units	Average area of farms
Under 86.....	43	71	\$120	13.9	178
86— 95.....	32	92	225	17.4	227
96—105.....	49	99.8	417	20.3	211
106—115.....	27	110	450	19.2	221
Over 115.....	44	129	675	23.3	218
Average (195 farms).....		100	\$385	19	207.5



One method of increasing farm profits is by increasing the yield of crops per acre.

It is interesting to note that there seems to exist a relationship between number of productive animal units, good crop yields, and labor income. Grouping the farms to show the per cent having low and high labor incomes as compared with the crop index emphasizes the need of crop yields as good or better than the average.

TABLE 11.—*Relation Between Crop Index and Labor Income by per cents.*

Crop index	Labor income			
	\$0 or less	\$1—\$500	\$501—\$1000	Over \$1000
Under 86.....	30%	47%	23%	.....
86—95.....	44%	28%	12%	16%
96—105.....	31%	31%	22%	16%
106—115.....	26%	30%	22%	22%
Over 115.....	16%	25%	32%	27%

No farms having yields 15 per cent or more below the average of the community received a labor income of over \$1,000, while of the farms whose yields were not less than 16 per cent above the community average, 27 per cent received labor incomes of over \$1,000 and 59 per cent received labor incomes of more than \$500.

It is possible to invest so much capital and labor in securing large crop yields that the resulting crop increase will not pay the cost. All our records indicate that this seldom happens in eastern Nebraska, and that the men who are farming a little better than the average of their community are receiving the best returns.

DIVERSITY.

In any prosperous region a majority of the farmers are usually found following in the main those farm practices which are most



The diversified farm of eastern Nebraska which produces both crops and livestock is usually more profitable than is the specialized farm

profitable. Experience and observation have taught them the type of farming and cultural methods which are best adapted to their region and to their particular farms.

Of the 195 farms included in this survey, 150 have a diversity index of 3 or more. This indicates that one-crop farming is not profitable, else it would be more generally followed.

In general, the operators with the highest diversity have the best labor incomes. No one crop occupies all of a man's time, and the farmer who works only half of the year cannot compete successfully with the man who provides profitable labor for the entire year. Table 12 shows the variation in labor income when the farms are arranged in classes according to their diversity.

TABLE 12.—*Relation of Diversity to Labor Income and Other Factors.*

Range of diversity	Average diversity index	Number of farms	Labor income per farm	Animal units per man	Crop acres per man	Crop acres per horse	Average area of farms (in acres)
1.0—1.9.....	1.3	8	\$105	6.9	72	18	137
2.0—2.9.....	2.4	36	355	9.5	94	24	184
3.0—3.9.....	3.4	85	358	11.9	97	24.6	218
4.0—4.9.....	4.4	47	426	12.4	104	26.7	227
5 and above....	5.5	19	560	13.1	122	27	213

The farmer who has the greatest diversity has the most live stock per man, crop acres per man, and crop acres per horse. The difference in crop acres per man and per horse is due in part to size of farm, but evidently in greater part to the fact that diversity provides a better distribution of man and horse labor thruout the year.

A considerable part of the care of live stock comes during the winter months when the crops provide little if any work. The farmer, being an economic producer, prefers working for a low wage to lying idle. The stock utilize considerable roughness which would otherwise be wasted, as well as some high-priced feed. Were it not for the fact that a large proportion of our live stock is produced in part upon cheap feed and by cheap labor, meat would be much higher than it is at the present time.

The diversity index as here used expresses only the diversity of products sold and not the diversity of products grown. No distinction is drawn between the man who produces the corn and alfalfa fed his cattle, and the man who purchases them, altho the man who grows his feed is certainly diversifying his farming to that extent.

While it is not easy to work out an exact table of diversity of production, the records indicate that such a table would show more characteristic results than are here presented.

EFFECT OF SEASONAL VARIATION.

In farm management surveys, it is essential that records be taken in an average year, or better yet, that an average of several years be used. The following table shows the difference in farm profits between selling corn at a high price in a year of good crops and purchasing at a high price for feed because of crop failure. It also gives the average labor income of nearly 600 eastern Nebraska farms including good, bad, and average years.

TABLE 13.—*Seasonal Variation and Labor Income in Eastern Nebraska. Interest Figured at 5 per cent.*

Year	Number of farms	Corn, average yield	Corn, average price	Labor income
1913.....	70	2	\$0.60	— \$189
1914.....	53	41	.58	+1,448
1911—14.....	597	27.1	.57	+ 521

The area in which the average gain in 1914 was \$1,448 is normally no more prosperous than the area in which the average loss was \$189 in 1913. The difference in profit was due to rainfall and to the high price received for the 1914 crop. The average corn yield for the years 1911-14 is lowered by the one year of crop failure, while the average labor income of the 597 eastern Nebraska farms upon which surveys have been made in some one of these years is slightly above the average of the farms for which more specific data have been given, probably because of the large proportion of 1914 records.

Of the 70 farms whose record is given for 1913, the best 10 had an average labor income of \$775 and an average area of 192 acres. Each of these farms had three main sources of income,—wheat, hogs, and cattle, and nearly all of them sold oats, horses, and poultry. Altho these farms had an average of 17 animal units but little feed was purchased. Nearly all that the farm produced was utilized, and the stock showed a good net profit. Labor and feed were used efficiently, and the farmer prospered even if his corn was an almost total failure.

Seasonal variation has a direct effect upon the size of farm business which is most profitable. Under very favorable conditions such as existed in 1914 in the area where the farms returned to the operator an average labor income of \$1,448, the labor income increases as the farm area increased. Under very unfavorable conditions the larger the farm, the larger the loss after the

family size of farm is passed. For example, in the Fillmore County area in 1913, the 10 largest farms lacked \$764 of paying 5 per cent interest upon the investment.

The farm which provides work for from one and one-half to two men or the equivalent thruout the year, employs man, horse, and machine labor about as efficiently as does a larger area. The big profit returned by the majority of these larger farms in favorable seasons is due largely to the profit on hired labor. Upon such farms there is naturally a loss on hired labor in very unfavorable seasons. The family size of farm furnishes about as much toward the family living as does a very large farm, and the wages paid hired labor is a much smaller proportion of the farm expenses.

OWNER AND TENANT.

In the preceding tables in this bulletin where farms are classified upon the basis of size, crop yield, and diversity, no distinction is drawn between owned and tenant farms. Labor income, in all of these tables, means the labor income of the farm, after interest at the rate of 5 per cent has been deducted from the net income. If a tenant paid to his landlord for rent more than 5 per cent upon the value of the land, his individual labor income was less than the labor income of the farm, while if he paid less than 5 per cent upon the value of the land his income was correspondingly larger.

The following table gives some of the characteristic differences between owner and tenant farmers and the difference in labor income.

TABLE 14.—*A Comparison of Owned, Partly Owned, and Tenant Farms.*

	Owner	Part owner	Tenant
Number of farms	76	35	84
Area in acres	214	222	200
Crop acres	149	180	158
Crop acres per man	86	103	104
Per cent of area in crops	69.6	81.1	79
Per cent of area in pasture	24.3	14.7	14.5
Per cent of area in clover and alfalfa	8	8.1	4.5
Receipts from live stock	\$1,475	\$1,362	\$795
Capital	27,078	28,011	25,673
Value home	1,347	949	831
Value other buildings	1,296	963	731
Farm receipts	2,526	3,028	2,447
Farm expenses	968	1,027	707
Farm income	1,558	2,001	1,740
Farm labor income	203	600	456
Operators' labor income	203	707	921
Landlords' rate of interest	....	4.1	3.1

The average size of the owned and tenant farms surveyed is practically the same. The slight difference in capital is accounted for by the difference in size and by the larger investment in buildings and live stock on the owned farms.

The owner receives a much larger per cent of his receipts from live stock than does the tenant, and has a larger per cent of his farm in meadow and pasture, the acreage of clover and alfalfa being almost twice as large.

The gross receipts of the owner are slightly larger than those of the tenant, while expenses are considerably larger. A part of the extra expenses of the owned farms are the depreciation and taxes upon the larger building investment. Feed and labor represent two other important items. As a rule the owner is older than the tenant and does less field work. Often considerable time is spent by the owner upon the farmstead, and in activities not directly connected with farm operations. It is usually the farm owner, who because of his permanency of residence and his active interest in the community is called upon to serve as school director, or church trustee, or director of the Farmers' Elevator Company. To fill satisfactorily any one of half a dozen such positions requires time and energy, which must necessarily be taken from farm operations.

The part owner has the greatest gross receipts, expenses, and farm income. He has the advantage of owning his own home, and usually farms the rented land with but little additional expense for horse or machine labor.

The tenant has the largest labor income, primarily because he pays as rent considerably less than 5 per cent of the value of the land. It is also doubtless due in some measure to the more exploitive types of farming followed and to the necessity of utilizing as much as possible of his time in productive labor. He can afford to spend less time than can the owner in beautifying the home place and in bettering the community.

The part owner rents land only, the tenant rents both land and buildings. Because of the interest on investment, depreciation, insurance, and taxes on the buildings the tenant farm with buildings nets less than does bare land. The part owner continually takes from the land he rents and puts nothing back so that this system of tenantry means very rapid soil depletion.

It has been for several years a matter of common knowledge among farmers that the owner of corn belt farm land receives a low rate of interest upon his investment. This has sometimes been attributed to the so-called "speculative value" at which land sells. The advocates of this theory argue that banks do not loan money upon even the best of security for less than 6

per cent. Therefore, if an acre of land valued at \$100 nets the owner \$3.50 annually it is actually worth only \$58.33. It sells for \$100 per acre not because of its earning capacity but because of the prevailing sentiment that corn belt land will continue to increase in value very rapidly, and the owner will make his profit, not from the crops grown on the land but from the advance in price.

The opponents of this theory admit that not only has land in eastern Nebraska and other parts of the corn belt increased very rapidly in price during the last twenty years, but that the indications are that there is apt to be some increase in the future. This rise will be slow, however, as compared with the last 20 years.

The man who buys corn belt land today buys primarily because he considers it a safe and satisfactory investment, and regards the hoped-for increase as a desirable feature but not of primary importance. The country banker may purchase land to inspire confidence in his bank, the retired farmer to obtain a known security, the typical American to satisfy his pride in land ownership. A farm furnishes the owner not only a safe investment but also furnishes him with a home and a job. Upon his own ability depends to a considerable extent the labor income which he will earn in addition to the interest upon his investment.

Interest rate, where capital is abundant, is governed largely by the security of the investment. Three per cent United States bonds sell at a premium because the security is good. We would laugh at the man who would say that a \$100 three per cent United States bond is actually worth only \$50, and that the difference between \$50 and the selling price is "speculative value". Exactly the same rule holds true with corn belt farm land. The low interest rate is due primarily to the security of the investment and not to land speculation.

The more speculative a security, the higher the interest rate which must be promised. As an illustration, we have 5 per cent school bonds selling at a premium, short-time personal notes at 6 to 8 per cent, chattel mortgages at 10 per cent, and mining stock which is confidently predicted to pay 50 per cent, but which guarantees nothing. None of these securities is considered as safe as corn belt farm land.

If at any time the income-producing power of land (as a whole) is increased, by increased productivity, by increased prices received for products, or by better farm management, we may expect to see the land rise in price until it reflects the increased income. Present indications are that the capitalization of corn belt farm land in the future will be at a lower rather than a higher rate of interest.

In addition to paying interest upon the investment, the farm should return the operator a labor income equivalent to that received by skilled workmen in other industries. It should not necessarily be equal in dollars, because a part of the farm income is received indirectly in the things furnished by the farm, such as a dwelling, fruit, vegetables, and meat.

In order to compare the labor income of tenants with the labor income of owners, it is necessary to place the farms upon the same basis so far as interest charges are concerned. The average per cent received by the 119 landlords is 3.41 per cent. The average for more than 400 tenant farms in eastern Nebraska is 3.43 per cent. If we exclude some farms rented from relatives on particularly favorable terms, the remainder averages approximately 3.5 per cent net income, and this figure will be used as a basis for comparing the owned and tenant farms.

TABLE 15.—*A Comparison of the Incomes of Owners, Part Owners, and Tenants (Interest on Real Estate Figured at 3½ Per cent and Other Capital at 5 per cent.)*

Tenure	Number of farms	Operators		
		Net income	Interest on investment	Labor income
Owner	76	\$1,558	\$998	\$560
Part owner	35	1,599	624	975
Tenant	79	923	117	806

The owner has a larger net income available for the support of his family than has the tenant because of the interest which he receives upon his investment. The tenant's labor income is the larger for reasons already explained. The owner and part owner, however, have a big advantage over the tenant in home conveniences. To them the farm is a permanent home, and not a place of temporary residence while accumulating a competence. The owner, especially the owner of middle age, usually feels justified in expending the major portion of his net income in supporting his family.

WHAT THE FARM CONTRIBUTES TOWARD THE FARMER'S LIVING.

Before any exact comparison can be made of the labor income of the farmer with the salary of the city worker it is necessary to consider what the farm furnishes toward the family living. The following figures were compiled from farmers' estimates of what they received from the farm in 1915.

TABLE 16.—*What the Farm Contributes Directly Towards the Farmer's Living.*

Richardson County	Tenant (12 farms)	Owner (28 farms)	Average (40 farms)
Area in acres.....	216	169	183
Value of house.....	\$988	\$2,154	\$1,804
Life of house—years.....	29	43	39
Cost of house—year.....	\$105	\$201	\$172
Pork.....	60	56	57
Beef.....	12	8	9
Mutton.....	1	1	1
Poultry.....	28	21	23
Whole milk.....	30	34	33
Other milk.....	1	1	1
Cream.....	33	34	34
Butter.....	41	41	41
Honey.....	0	3	2
Eggs.....	33	27	29
Apples.....	3	7	6
Other fruit.....	1	7	5
Irish potatoes.....	16	16	16
Other vegetables.....	19	20	20
Wheat exchanged.....	4	4	4
Wood.....	13	25	21
Cobs.....	3	3	3
Total.....	\$405	\$509	\$477

Richardson County is one of the oldest counties in the state and one of the most prosperous. Because of this, the dwellings average unusually good. More fruit is furnished than in localities where it does not thrive as well. In many parts of the state little fuel is furnished by the farm. Even after making all possible allowance it seems certain that the average farm of eastern Nebraska contributes upwards of \$400 to the family living.

The following table gives the amounts of various products consumed and the price charged. A few products such as milk are listed higher than customarily valued on the farm, yet no higher than the wholesale price for which they are usually sold.

TABLE 17.—*Quantity of Various Products Contributed by the Farm.*

Richardson County, 40 Farms				
Farm area, 183 acres; number in family, 4.7; life of farmhouse, 39 years; value of farmhouse, \$1,804.				
Items in living	Number	Pounds	Price	Total
Yearly cost of house.....	...	...	...	\$172
Pork.....	3	816	\$6.98	57
Beef.....	...	128	6.70	9
Mutton.....	...	12	7.00	1
Poultry.....	51	...	.46	23
Whole milk.....	251 gal.	...	.13	33
Other milk.....	43 gal.	...	.03	1
Cream.....	305 pts.	...	.11	34
Butter.....	164 lbs.	...	.25	41
Honey.....	11 lbs.	...	.15	2
Eggs.....	173 doz.	...	.17	29
Apples.....	15 bu.	...	.40	6
Other fruit.....	...	...	...	5
Potatoes.....	31 bu.	...	.53	16
Other vegetables.....	...	...	...	20
Wheat exchanged.....	4 bu.	...	1.00	4
Wood.....	9 loads	...	2.29	21
Cobs.....	3 loads	...	1.00	3
Total.....	...	...	...	\$477

THE FARMER'S REAL RETURNS.

If we deduct 10 per cent from the Richardson County figures because they are doubtless higher than the average, we find the farmer receiving the following income:

TABLE 18.—*Farmers' Real Returns in Eastern Nebraska.*
Interest on Real Estate Figured at 3½ per cent, and on Other Capital at 5 per cent.

	Tenant	Owner
Labor income.....	\$806	\$560
Furnished by farm.....	365	458
Basis of city workman.....	\$1,171	\$1,018

Compared with the wages paid unskilled labor in cities this income is good. Compared with the hourly wages of 50 to 75 cents paid carpenters, masons and other workingmen who have

no more real skill than the farmer, it does not seem unduly high. It certainly does not bear out the widely disseminated theory that the farmers are securing enormous profits and are directly responsible for the high cost of living. Judging from the constantly increasing number of business and professional men these fields must offer at least equivalent monetary opportunities.



Poultry is one of the minor products upon nearly all eastern Nebraska farms. No small part of poultry profits comes from the labor of boys and girls.

A part of the farmer's reward will always come from the opportunity of operating an independent business instead of working for wages. During periods of depression when the city workman is most apt to be idle the farm can be made to provide the major portion of the necessities of life. The farm usually furnishes employment for the entire family, and the family often operates the farm without hiring additional labor. On the farms surveyed, approximately one-half of the work aside from that done by the operator was performed by boys under 21 years. The training received from the performance of definite daily tasks is of more value to the farm boy than is his labor to his father. These factors will always aid in keeping average farm profits at a low figure.

SOME SUCCESSFUL FARMS.

The farm of today furnishes an excellent opportunity for efficient business organization and management. The following

table compares the capital, receipts, expenses, and labor income of 195 farms, with these same items for 10 of the best "family farms".

TABLE 19.—*Summary of Business of 10 Successful Farms Compared with Business of All Farms Surveyed*

	10 Farms		195 Farms	
	Value	Totals	Value	Totals
<i>Capital</i>				
Real estate.....	\$26,865		\$23,816	
Live stock.....	2,377		1,793	
Feed.....	591		414	
Machinery.....	516		390	
Cash.....	280	\$30,629	233	\$26,646
<i>Receipts</i>				
Crops.....	\$2,257		\$1,286	
Live stock (Net inc.).....	1,831		1,162	
Miscellaneous.....	26		85	
Inc. in feed inventory.....	....	\$4,114	50	\$2,583
<i>Expenses</i>				
Current.....	\$934		\$743	
Depreciation.....	153		123	
Dec. in feed inventory.....	114	\$1,201	....	\$866
<i>Farm income</i>		\$2,913		\$1,717
Int. on capital at 5%.....		1,531		1,332
<i>Labor income</i>		\$1,382		\$385

The difference in capital is not large enough to account for the difference in receipts, expenses, and labor income. The successful men did not have a large labor income because their expenses were small but because their receipts were large. Profits come not so much from never spending money as from getting good value for all money expended.

It is interesting to note the factors which were most important in securing the added profit.

TABLE 20.—*Factors Affecting Farm Profits. 195 Eastern Nebraska Farms.*

	10 Efficient farms	Average (195 farms)
<i>Size of business</i>		
Farm area, acres	228	207.5
Crop area, acres	187	158
Productive animal units	25.5	19
Total capital	\$30,629	\$26,645
Total receipts	\$4,114	\$2,583
Total expenses	\$1,201	\$866
<i>Diversity of business</i>		
Diversity index	3.8	3.5
<i>Quality of business</i>		
Crop index	115	100
Crop acres per man	95	98.5
Productive animal units per man	15.5	11.4
Crop acres per horse	27.5	24.7

The difference in capital, crop area, and productive animal units is not great enough to account for any very large part of the difference in gross receipts. The better farms are more diversified, but the difference is not great since nearly all the farms of the region are diversified farms. Unquestionably, then, these ten farms are prosperous because of their organization and because of the quality of their business. Their crops average 15 per cent better than their neighbors, and this yield is secured without increased cost, as productive animal units per man, and the crop acres per horse are greater for these ten farms than for the average of all the farms, while crop acres per man is but little lower.

These farmers not only kept more live stock but cared for it more efficiently. Allowing market price for all hay, straw, and grain fed, and rent for pasture including cornstalks pastured, these farms received \$1.33 for each \$1 worth of feed consumed, in addition to the meat, milk, and other products consumed on the farm. On some farms in the area, rough feeds were wasted, and upon other farms the stock was not economically handled.

TABLE 21.—*Sources of Income. Average of 10 Successful Farms.*

Corn sales	\$751
Wheat sales	1,238
Oat sales	83
Hay sales	152
Hogs ¹	1,154
Cattle, ¹ including dairy products	482
Horses ¹	96
Poultry ¹	84
Miscellaneous receipts	74
Gross receipts	\$4,114

No farm of the ten had any sales except of the staple products of eastern Nebraska. Occasionally a man may attain success producing figs or thistles, ginseng or onions, muskrats or squabs, but on the average the man is most apt to prosper who grows the products which he knows and for which there is a well-established demand. The growing of nearly all unusual products demands special skill; their sale, a special market; and too often their profit depends upon unusual conditions.

While there is nothing spectacular in the results obtained by these ten farmers they nevertheless are worth more than passing notice. The type of farming which they represent is the type which is doing most to bring prosperity to their part of the corn belt.

EDUCATION.

Education is a factor not always considered in accounting for the success or failure of individual farmers. Nebraska records indicate that the farmer with a college education has a decided advantage over the man who has attended only the common school.

TABLE 22.—*Relation of Education to Labor Income. (409 Nebraska Farmers, 1914.)*

Education	Number of farms	Labor income	Increase over common school
8 grades or less	299	\$550	.....
Attended high school	96	727	32.1%
Attended college	14	835	51.8%

¹The receipts for stock are found by subtracting the sum of the purchases and what is on hand at the beginning of the year, from the sum of the sales and that on hand at the close of the year

Only a part of those who had attended high school had completed 12 grades. This group also included Business College students.

Normal School students are included among those who attended college, and not all of this group are graduates of an institution of higher education. While the number is so small that we cannot draw definite conclusion as to the exact monetary value of a college education, it can be said very definitely that there are no indications of the once prevalent theory that "book learning" renders a man impractical and unfits him for farming.

CONCLUSION.

If farm management surveys in Nebraska have proven anything, it is that farming is a business and that the farmer is a business man. He can depend neither upon some other man to do his thinking for him nor upon strikes and combinations to give him either higher wages or shorter hours. While the prices of many commodities are apparently influenced, if not entirely controlled by agreements, trusts, and pools, the business of farming yet remains, and doubtless will continue to remain upon a competitive basis.

To meet the competition of other producers, not only in this but in foreign countries, Nebraska farms must be organized upon efficiency lines. A good balance must be maintained between crops and live stock so that all crop residues are utilized and a full year of productive labor provided.

The largest item in the cost of production is labor. Therefore the most important problem of production for the Nebraska farmer to solve is how labor can be used most efficiently. The men who arrive at the most satisfactory solution of the question are the men who will have, other things being equal, the largest labor incomes. Farm area, diversity of enterprises, intensity of culture, and type of farming are determined primarily by the area, diversity, culture, and type which permit the most efficient use of labor. In deciding these questions personal experience is of first importance. Farm management surveys would add to personal experience the combined experience of other men.

A large part of the survey records upon which this bulletin is based were taken by advanced students in the Department of Farm Management. E. L. Currier conducted the survey in Platte County, Arthur Medlar in Fillmore County, L. F. Garey in Madison County, Boyd Rist in Richardson County, and H. M. Dixon of the Office of Farm Management United States Department of Agriculture in Merrick County. The data upon what the farm furnishes toward the family living was collected by J. F. Hendricks. Some of the tables contain data from records taken in connection with the Farm Management demonstration work conducted cooperatively by the United States Department of Agriculture and the Extension Service and Department of Farm Management of the University of Nebraska.

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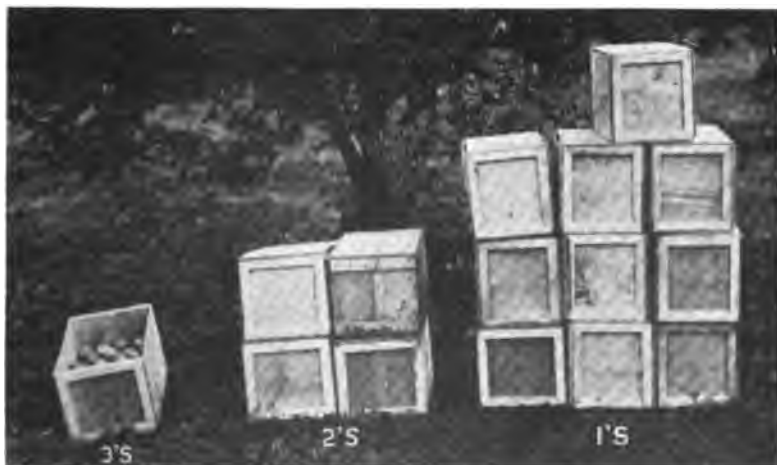
THE UNIVERSITY OF NEBRASKA
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VOLUME XXIX, ARTICLE II

WHY, WHEN, AND HOW TO SPRAY

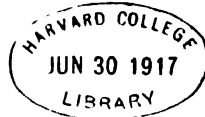
BY J. RALPH COOPER

DISTRIBUTED FEBRUARY 15, 1917



FRUIT FROM A SPRAYED TREE GRADED INTO FIRSTS, SECONDS, AND THIRDS

LINCOLN, NEBRASKA
U. S. A.



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¹Resigned

²Detailed from Office of Dry Land Agriculture, United States Department of Agriculture, Washington, D. C.

WHY, WHEN, AND HOW TO SPRAY¹

BY J. RALPH COOPER

The time has arrived when spraying must be considered as a part of the regular orchard work. Fruit growers can no longer secure, or expect to secure, profitable returns from their orchards unless they practice thoro and systematic spraying. During the last three seasons an average of 72.5 per cent of the fruit in unsprayed orchards was so badly damaged by insects alone that it was fit only for vinegar. Fungous diseases have caused almost as much damage. Insects and fungi have caused a total loss in many orchards. The average loss due to both in the orchards under observation during the last three years was 86.6 per cent.

During the seasons of 1913, 1914, and 1915, extensive tests were made in orchards in various parts of the state to determine how much of this loss could be prevented by spraying, what materials to use, and how and when to apply them. It was found that practically all loss from either insects or fungi can be prevented by spraying, at an average cost of about 24 cents per tree for an ordinary mature tree.

The average value of fruit in unsprayed orchards, determined by the price which the fruit actually brought on the market, was \$1.67 per tree. The average value of fruit in the sprayed orchards was \$7.38 per tree. After paying the cost of spraying, this left a net gain of \$5.47 per tree due to spraying.

In order to control insect and fungus enemies it is necessary to understand their life history and habits. Much labor and money is often wasted in spraying at the wrong time. In spraying for chewing insects of any kind, the poison must be placed on the plants before or just as soon as the insects arrive. Hence, it is imperative that the orchardist know at what stage of its life cycle the insect feeds on the plants and at what season of the year the feeding stage occurs. If spraying is done too long before the insects appear, the material may be washed off; but the insects may have burrowed out of reach of poison if it is not applied until after they have begun feeding. In spraying for fungous diseases the fungicide must be applied before the spores germinate. If the spores have germinated and parts of the new growth have entered the foliage or fruit, it is impossible to prevent fungus injury.

¹This is a brief review of Research Bulletin No. 10, "Spraying Experiments in Nebraska," issued by this Station. Anyone interested in the details of the investigations will be furnished, on application, a copy of the complete bulletin.

SPRAYING FOR THE CONTROL OF INSECTS

CODLING MOTH

This insect passes the winter as a larva, or worm. About the time apple trees are in full bloom these worms begin pupating, or transforming themselves into moths. The moths emerge and begin laying eggs about three weeks after the petals have fallen from the apple blossoms. The first or spring brood of worms hatch from the eggs within a very few days. Some of them go immediately to the fruit while others feed a day or two on the leaves and then move to the fruit. About 80 per cent of the worms enter the apples at the calyx end. The remaining 20 per cent enter the sides of the apples where two fruits touch or where a leaf or twig touches the fruit. The worms live to maturity in the fruit, emerge, and transform to moths which in turn lay eggs for a second or summer brood of worms. Normally there are but two broods of worms in Nebraska, but the length of time necessary for eggs to hatch and for worms to grow to maturity and transform to moths depends upon the temperature and weather conditions. During hot, dry seasons much less time is required than during cool, moist weather. Hence, worms are much more abundant. The chart shown in fig. 1 will give an idea of the abundance and rate of development of the different stages in the life history of the insect during the hot, dry season of 1914; while the chart shown in fig. 2 will show the same for the cool, moist season of 1915.

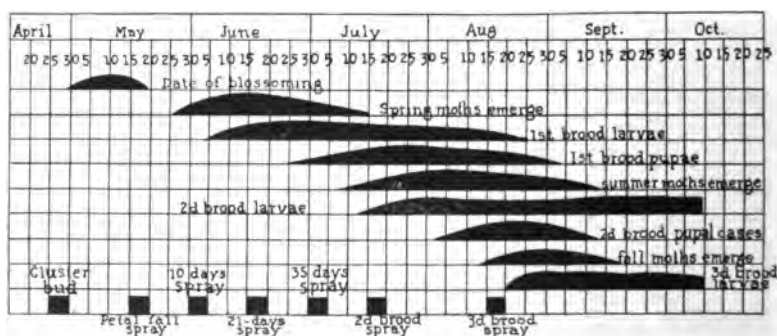


Fig. 1—Shows blooming period of apples, rate of development of codling moth, and dates when spraying was most effective for both codling moth and scab in 1914

The codling moth feeds only during the larval or worm stage. Hence, in order to prevent injury, spraying must be done just before the eggs hatch. But by the time the first-brood eggs

begin to hatch, the calyces of the apples have all closed, and the worms which enter the apples at this point are safe from poison because the spray cannot be forced into the closed calyx cups. The calyx cups may be filled with poison if spraying is done immediately after the petals have fallen.

After studying the life history of the insect it is very evident that three sprays are necessary to prevent damage to the fruit during a normal season,—one just after the petals have fallen; one three weeks later, just before the first-brood eggs begin hatching; and another just before the second-brood eggs begin to hatch, as indicated by the black squares at the bottom of the chart in fig. 2. But during hot, dry seasons it may be necessary to spray four or even five times as indicated by fig. 1.

The efficiency of a spray schedule for the control of codling moth depends very largely upon the thoroughness of the petal-fall application. However, this application is not in itself sufficient, even tho every calyx receives a good dose of poison. Approximately 20 per cent of the first-brood "worms" normally enter

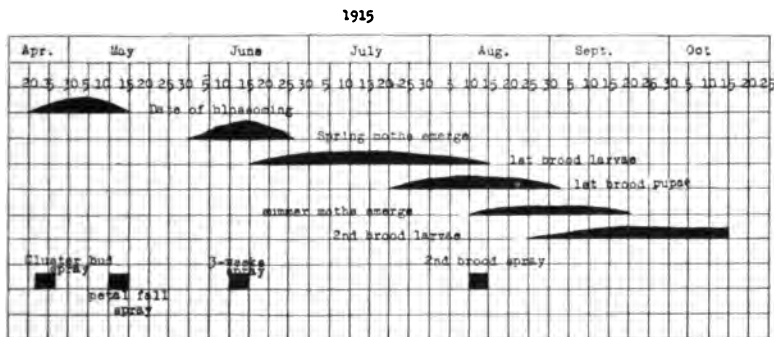


Fig. 2—Shows blooming period of apples, rate of development of codling moth, and dates when spraying was most effective for both codling moth and scab in 1915

the fruit at various points other than the calyx, on unsprayed trees. The spray materials lodged in the calyces certainly will cause some of the larvæ which would otherwise enter the calyx to seek other points of entrance, so that the percentage of the larvæ which enter the fruit from other points must be appreciably increased. This is borne out by the fact that even with the most thoro calyx spraying during the last three seasons 20 to 40 per cent of the worms were controlled by the late applications.

The first application should be made immediately after two-thirds to three-fourths of the petals have fallen. The spray

should be applied as a coarse mist directly against the face of the open calyces. In order to apply the material properly the greater part of the spraying should be done from the tower. A good arrangement, where the trees are large, if a large capacity machine is used, is for two men to work from the tower and one from the ground. The material should be applied downward with a stroking motion of the rod, beginning at the extreme tips of the branches and following down to the trunk. In this way, there is a minimum danger of missing any of the calyces. More material is needed for this application than for any other. The pressure should be 225 to 250 pounds.

The next spray should be applied about three weeks later and should consist of a fine mist. The main object of this application is to cover all growing parts of the tree thoroly. The material should be directed both above and below with long stroking motions, beginning at the tips of the branches. The exact time for applying this spray is immediately after the moths begin to deposit their eggs. The correct time may be determined by collecting larvæ early in the spring and keeping them confined until they pupate and emerge as moths. Repeat the operation for the second brood and if necessary, the third brood. By doing this and noting weather conditions, every orchardist should be able to spray so that he may secure the greatest efficiency from the materials used. The best materials will give, at best, poor results if used at the wrong time.

The third (or second-brood) spray should be applied immediately after the eggs laid by the first brood have hatched. It should be applied in the same manner as the preceding spray.

In abnormal seasons like that of 1914, when, owing to favorable conditions, the moths emerge early and multiply rapidly, a third-brood spray is necessary where thoro spraying during previous seasons has not reduced the infestation to a minimum.

THE PLUM CURCULIO

The primary injury done by the curculio consists of small holes made in the apples in feeding and for depositing eggs. This is only a small part of the injury, however. These punctures cause the fruit to become ill-shaped and knotty, and admit fungi. The beetles or adults pass the winter under trash and rubbish, and come out and begin feeding on the new leaves before the blossoms open. As soon as the fruit sets they begin feeding on it and depositing their eggs.

Considering the following facts known in regard to the life history of the plum curculio, it is evident that by taking advantage of certain habits of the insect its control is comparatively easy and certain:

- (1) The adults hibernate during the winter under trash and rubbish in the orchard.
- (2) After a winter of fasting they are very voracious and in the spring commence feeding on the new leaves and buds before the blossoms are open.
- (3) The larvæ are unable to live to maturity in the apples when they remain on the tree. Only those larvæ which are in the apples that fall early reach maturity and become beetles.
- (4) The larvæ begin entering the ground to form their pupal cases and transform into beetles about the middle of July. This continues up to the middle of August or later. The pupal cases are placed at an average depth of one to two inches.

Therefore, control measures which suggested themselves and which have proved effective are: the removal of trash and rubbish, accompanied by early spring cultivation; thoro spraying with arsenate of lead before the blossoms open, followed by the regular codling moth schedule; the removal of windfalls, which may contain larvæ, from the orchard; and, lastly, thoro cultivation of the orchard from the middle of July to the middle of August.

SPRAYING FOR THE CONTROL OF FUNGOUS DISEASES

APPLE SCAB

One of the determining factors in the production of apples in Nebraska is the prevalence of apple scab. Notwithstanding the fact that its destructiveness is well known and that reasonably sure methods of control have been published, this disease alone damages more than 50 per cent of the fruit of the state. As a matter of fact, the loss is often even greater than it appears. The young apples drop prematurely, due to the attacks of the fungus upon the flowers before and during the blossoming period, and on the young fruit later. This was especially noticeable during the seasons of 1913 and 1915. At blossoming time the bloom was as heavy on the unsprayed as on the sprayed trees. The set of fruit on the sprayed trees was much heavier than on the unsprayed trees, and the number of apples which dropped prematurely much less. In unsprayed orchards the foliage is sometimes so severely injured that the fruit never attains salable size, and scarcely any growth is made by the trees. It often takes two or three years of thoro spraying to bring the trees back to normal growth and productiveness. Scab also impairs the keeping quality of fruit. At harvest time in 1915 several boxes of Winesap, Arkansas, and Ben Davis apples were stored.

A part of each variety came from trees having considerable scabby fruit and a part from trees having no scab. All the fruit was free from visible scab when packed. Some of the fruit was placed in cold storage and some in cellar storage. When the fruit was examined in January, 1916, 10 per cent of the fruit in cold storage was scabby and 68 per cent of the fruit in cellar storage was scabby. The fruit in cold storage was held a few days before being stored and was taken out 2 days before being examined.



Fig. 3—Shows a leaf affected with apple scab and one free from scab

Time of Infection—Apple scab is a cool weather disease and thrives best under conditions that allow shade and moisture. Under ordinary conditions the period of greatest infection is from the time the leaf buds begin to unfold until two or three weeks after the petals fall. Where there is an abundance of dead leaves under the trees the period of infection may be prolonged by the continued development of spores or seedlike bodies in the leaves during a long period of wet weather.

During the cool, damp weather of 1915, there was a great deal of loss due to a second infection occurring from the latter part of July to the middle of August. To this late infection is attributed a large part of the loss in storage due to scab injury.

The writer is of the opinion that infection occurred before picking, because clean fruit from a scab-free orchard developed no signs of scab, even tho stored in the same package with heavily scabbed fruit in the same cellar where so much infection was found.



Fig. 4—A light infection of scab on the fruit

Varietal Susceptibility—It has been found that none of the common varieties are entirely free from scab, altho many varieties exhibit a great deal of resistance.

From the observations made in various orchards in the state and in the variety orchard at the Experiment Station the varieties have been tentatively grouped as follows:

Practically Resistant	Moderately Resistant	Susceptible
Wagner	Jonathan	Arkansas (Mammoth)
Oldenburg (Duchess)	York (Imperial)	Blacktwig)
Wealthy	Ben Davis	Ralls (Genet)
Patten Greening	Windsor	Northern Spy
	Gano	Red June
	Grimes (Golden)	Virginia Beauty
	Missouri (Pippin)	Yellow Transparent
	Salome	Sheriff
	Champion	Maiden Blush
	Minkler	Walbridge
	Northwest Greening	Early Harvest
	Rome (Beauty)	Fameuse (Snow)
	Delicious	King David
	Red Astrachan	Chenango
	Wolf River	Paragon
	Malinda	
	Willow Twig	
	Stayman (Winesap)	
	Chicago	
	Utter (Red)	

Scab was always found to be more prevalent where no cultivation was practiced and decidedly less in evidence where thoro, early and late cultivation was practiced.

Sanitation, that is, the removal of old leaves, windfalls, and mummied apples, together with clean culture, will go a long way towards controlling the scab infection.

The proper spacing of the trees in an orchard, good air drainage, and the right amount of pruning will lessen the infection of scab to some extent. However, with an ideal orchard and the best methods of sanitation, clean fruit cannot be grown in Nebraska unless the orchards are properly sprayed.

Spraying will control the disease if done at the proper time. This time depends upon the time of infection. The spray must be applied before the infection in order to prevent injury. Therefore, since there is always more or less infection at or just before the time the blossoms are out, if the weather conditions are favorable, it follows that spraying for scab must be done before this time. What is known as the cluster-bud stage—just as the flowers of the clusters are separating and showing “pink” but before the individual blossoms open—is the proper time for this application.

A second application at the petal-fall stage and another two to three weeks later are as a rule required to insure protection. During this time new surfaces of fruit and foliage are being rapidly exposed and are liable to infection. Another spray in the latter part of July or the first part of August may be necessary to prevent late infection in seasons such as that of 1915.

In order to secure the best results it is necessary that the grower watch the weather conditions carefully and regulate his schedule accordingly. Thousands of bushels of apples have been lost in this state because the grower delayed spraying on account of rainy weather, fearing the spray would wash off. This is just the time when protection is needed to prevent infection. There is rarely a season in Nebraska when, because of wet weather, there is not sufficient time to spray; and if it is only possible to work for a part of a day at a time, spraying should proceed. Ordinarily the spray material will dry in 30 minutes of sunshine so that it will adhere well thru any ordinary hard washing rain.

APPLE BLOTCH

This fungus attacks fruit spurs, twigs, and rapidly growing shoots as well as the leaves and fruit. On the fruit spurs, twigs, and water sprouts, small cankers are formed in which the fungus lives over winter.

The fungus injures the leaves by killing the tissues in small

irregular spots. These spots often appear in great numbers scattered over the surface of the leaf. Badly infected leaves turn yellow and drop prematurely, or die and remain on the tree.

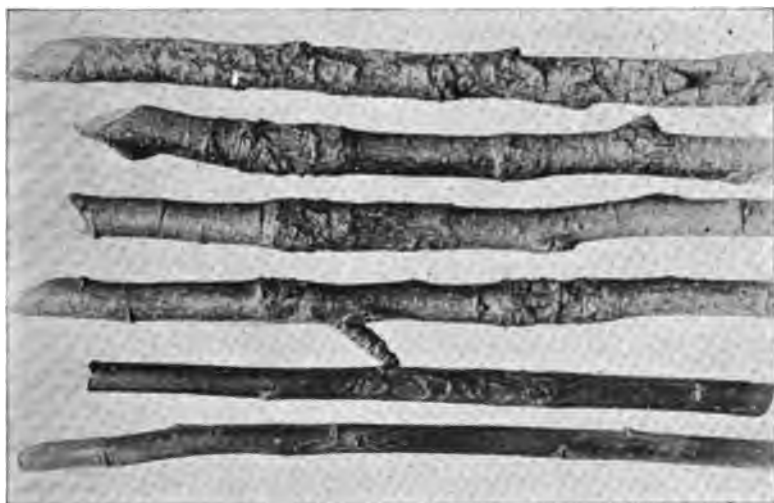


Fig. 5—Blotch cankers on twigs

On the fruit, the disease first appears as a very small, light brown blot with very irregular fringed edges. The blotches spread rapidly, and often, where they are numerous, run together and cover almost the entire surface of the fruit. The fungus kills only the outer portion of the skin so that the continued growing of the fruit causes the fruit to crack.



Fig. 6—Blotch on mature fruit

Infection—The cankers in which the fungus passes the winter are the chief sources of infection. Spores are produced during the warm, moist weather of spring. They are readily carried by the rain and other agencies to the young fruit, leaves, and twigs, producing the first spring outbreak of the disease. The most extensive infection begins 4 to 5 weeks after the petals have fallen, altho some infection probably occurs during the remainder of the growing season. Bordeaux mixture is superior to lime sulphur for controlling blotch. For this purpose the 3-4-50 (3 lbs. of bluestone, 4 lbs. of lime, and water to make 50 gallons) is recommended; tho, if a good grade of fresh stone-lime is used (not air-slaked or hydrated lime), the 3-3-50 formula is equally good. During dry weather the 4-4-50 formula has given good results but is not so safe when used during wet weather.

Three weeks after the petals fall is soon enough for the first spray for blotch; and in orchards no more badly infected than 15 per cent to 45 per cent, this spray, followed by another application of fungicide when spraying for the second brood of codling moth, is usually sufficient. In orchards more heavily infected, another application of Bordeaux mixture 15 to 20 days after the 3-weeks spray should be made.

Ordinarily only such varieties as Mann, Missouri, Maiden Blush, Northwest Greening, and Ben Davis are seriously injured by blotch.

CEDAR RUST

This disease has two stages. The first stage occurs not on the apple but on the foliage and twigs of cedar trees, where it appears during the fall and winter as small, brown knots commonly called "cedar apples." With the warm weather of spring these "cedar apples" produce large masses of orange-colored jellylike material which contains spores or seedlike bodies. These spores are carried by the wind and other agencies to apple trees, where they produce the orange-colored rough spots on leaves and fruit.

Little cedar rust has been noted in Nebraska during the last few seasons owing, no doubt, to the extreme dry weather. However, the disease often proves very destructive. The disease may be controlled by destroying all cedar trees in the neighborhood of the orchard, but often the cedar trees are too valuable to sacrifice.

A report published from this Station by Emerson in 1903 (Bul. 88) shows that the first or cluster-bud spray has comparatively no effect on the amount of injury from rust, but that the petal-

fall spray and the one following give a very high per cent of control.

In order to secure the best results, spraying should be done as soon as the knots on the cedar trees, known as "cedar apples," begin to enlarge and show gelatinous orange-colored exudations.



Fig. 7—Cedar rust on apple leaves

SOOTY BLOTCH AND FLYSPECK

Sooty blotch and flyspeck are considered by most pathologists to be caused by the same fungus and were so treated in the observations on which this report is based. The fungus attacks the fruit late in the season and works entirely on the surface. The discoloration reduces the salability of the fruit. The fungus is most abundant during wet seasons and does the most damage

to fruit in the lower parts of the orchard where air drainage is poor, where the trees stand too close together, or where they are not properly pruned.

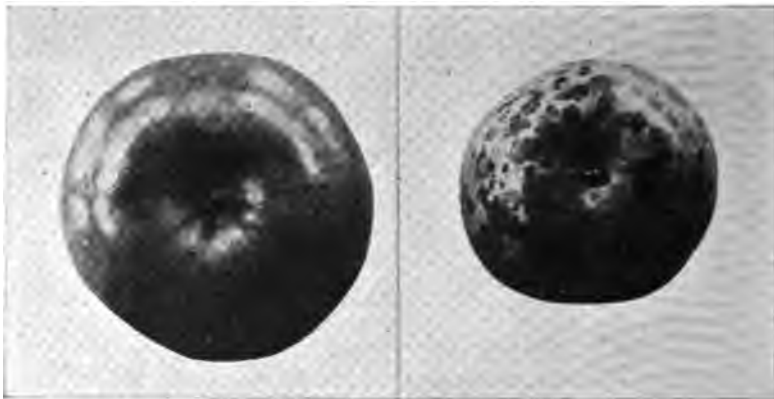


Fig. 8—Sooty blotch or fly speck on fruit

Observations indicate that with proper pruning to admit air and light the disease will be incidentally controlled in spraying for blotch and scab.

BORDEAUX MIXTURE VS. LIME SULPHUR

Bordeaux has long been considered as the standard fungicide, but it causes so much injury to both fruit and foliage of apple trees that it has been thought advisable to secure a substitute. The most serious injury occurs when Bordeaux is used for the petal-fall or calyx spray. As the fruit grows older it is less liable to injury, tho if the spraying is done during wet weather, or if wet weather follows soon after the spraying, some injury may occur even after the fruit is full grown. Very little injury, however, follows the use of Bordeaux for the last spray of the season and there is practically no injury when Bordeaux is used for the cluster-bud spray.

Attempts have been made at the Station to prevent Bordeaux injury by adding an excess of lime to the mixture when spraying, or by spraying the trees with lime water after each rain, but no benefits were secured from either method.

Lime sulphur has proved the most satisfactory substitute for Bordeaux. However, this material also causes some injury to fruit and foliage when spraying is done during extremely hot,



Fig. 9—A severe case of Bordeaux injury on fruit

dry weather. Lime sulphur has been found practically as effective as Bordeaux in controlling all of the ordinary fungous diseases except apple blotch. For the control of blotch, Bordeaux is much more effective.

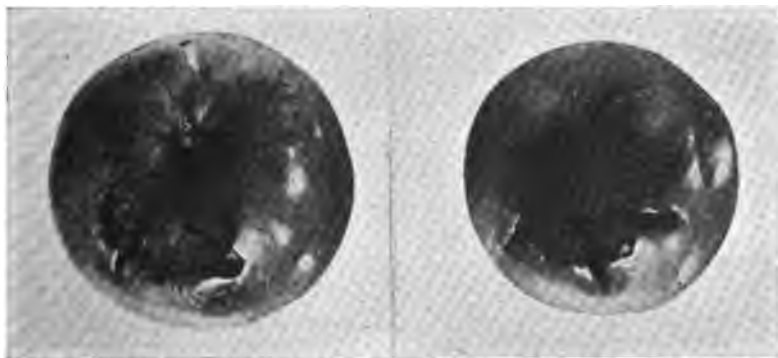


Fig. 10—Lime sulphur injury on fruit

Because Bordeaux injury is greatest during wet weather and on young fruit and because lime sulphur injury is greatest during dry, hot weather, it is possible to interchange these two fungicides in the schedule so that practically no spray injury will result.

Neither Bordeaux nor lime sulphur will produce russet on the fruit when used for the first or cluster-bud spray.

Lime sulphur must be used for the calyx or petal-fall spray.

Lime sulphur should be used for the 3-weeks spray except on varieties infected with blotch. Even if blotch is present lime sulphur should be used if wet weather prevails, but an application of Bordeaux should be made as soon as possible after the weather becomes clear and settled.

If a fungicide is used for the fourth spray, it should be Bordeaux if the weather is extremely hot and dry, and lime sulphur if the weather is cool and damp. If only one fungicide is to be used thruout the season, it should be lime sulphur. As a rule even where russetting is negligible, fruit sprayed with Bordeaux is not so bright colored and attractive as fruit sprayed with lime sulphur.

It is the opinion of the writer that a great deal of the so-called spray injury to the leaves is due to infection by fungous diseases. It was noticed that during the last few seasons both Bordeaux and lime sulphur injury were as a rule more noticeable in orchards where there was an infection of blotch or scab. The spray when applied where infection has already occurred finds a ready entrance into the leaves at the affected points and easily destroys the surrounding portions.

HOME-BOILED VS. COMMERCIAL LIME SULPHUR

A comparison of the efficiency of home-boiled and commercial lime sulphur was made in 1915. Altho no definite conclusions could be drawn, the indications are that the home-boiled product when properly made is as effective as the commercial. Slightly less spray burn was found on the plats sprayed with the home-boiled material where only the clear liquid was used.

Lime sulphur containing sludge causes more severe burning than where the clear liquid is used. This was demonstrated in a near-by orchard where lime sulphur containing sludge was used on a part of the orchard while the remainder was sprayed with the clear liquid. Both leaves and fruit were damaged where the sludge was used. Grit or hard materials of any kind in the solution may cause russetting by being thrown against the surface of the fruit with considerable force, thus destroying the waxy covering of the cells or the cells themselves and allowing them to be more easily injured by the corrosive action of the spray.

COMMERCIAL PREPARATIONS SOLD AS FUNGICIDES

Several preparations, sold as fungicides by various companies, have been tried out, but so far nothing has been found to take the place of the two standard fungicides. Several brands of prepared Bordeaux were found to control fungous diseases

practically as well as the regular Bordeaux but did considerable more damage to fruit and foliage.

Atomic sulphur and soluble sulphur were used with the results that, while scab was usually controlled, the damage to fruit and foliage was so great as to make the use of either disastrous. Sulphur in either form would be desirable because of convenience in handling and reduction in freight, could the disagreeable feature of injury to the fruit be eliminated.

PENETRATION VS. MIST SPRAYING

The filling of all calyx cups and the thoro covering of all parts of the tree, fruit, and foliage with the least expenditure of labor and material and with a minimum amount of injury to the fruit constitute efficiency in spraying. The evidence secured during the last three seasons indicates that more injury is done by using solid stream or Bordeaux nozzles than by using those of the hollow stream or mist type, while there is practically no more efficiency secured. Even for the petal-fall spray, nothing is gained by using the Bordeaux type of nozzles. Coarse mist nozzles operating under 225 to 250 pounds pressure will throw a penetrating heavy mist several feet thru the foliage of an ordinary tree and will fill the calyx cups as readily and cover all parts of the foliage more evenly and thoroly than will the Bordeaux type of nozzle.

CUMULATIVE EFFECTS OF SPRAYING

The argument is often advanced that it does not pay to spray when a crop is not expected, or when the insect infestation or the fungous infection is light. This is a fallacy. The orchardist cannot afford to neglect spraying just because there is no promise of immediate returns. Spraying will more than pay expenses in the benefit to the following year's crop. At Florence in 1913, only a part of a 30-acre orchard was sprayed. The whole orchard was sprayed in 1914 and 1915; but at harvest time in 1915 the effect of the thoro spraying received by but a part of the trees in 1913 was still decidedly noticeable. The effects were so evident that the packers, who were not acquainted with the facts of the case, found a decided difference in the grades of fruit from the two parts of the orchard.

At Omaha one plat was chosen in an orchard which had been well sprayed for five years and one in an adjoining orchard which had never been sprayed. Neither plat was sprayed in 1915. In the first plat the 1915 crop showed 11.15 per cent insect injury and 33.12 per cent fungous injury. The second plat showed 94.62 per cent insect injury and every apple was injured by fungi.

At Beatrice two plats were chosen, one of which was sprayed in 1914 and one which had never been sprayed. Both were sprayed in 1915. The fruit from the first showed 5.75 per cent insect injury and 22.84 per cent fungous injury. The fruit from the second showed 12.83 per cent insect injury and 57.32 per cent fungous injury.

These data, while not exhaustive, serve to indicate the importance of continued effort in insect and disease control.

COST OF SPRAYING

The cost of spraying depends greatly upon the efficiency and capacity of the machine used. The capacity of the spray machine must be determined by the size of the orchard and the length of time available for applying the petal-fall spray. The time from the falling of the petals to the complete closing of the calyces is usually seven to ten days. It is not safe to allow more than what can be sprayed in five or six full days for one machine.



Fig. 11—A good type of barrel pump

A barrel pump is efficient for orchards of 300 trees. During the three seasons the average cost of spraying with a barrel pump, including labor and material, was 30 cents per tree for four sprays.

A double acting horizontal or duplex hand pump was found to be efficient for 300 to 400 trees. The average cost of spraying with this outfit was also about 30 cents per tree for four sprays.

Gasoline-engine-driven pumps range from 3 gallons per minute to 12 gallons per minute in capacity, and are efficient for about 150 trees for each gallon per minute. This would be 450 trees for the smallest and 1,800 trees for the largest outfits. The average cost of spraying with power outfits during the past three seasons ranged from 20 to 25 cents per tree.



Fig. 12—A Triplex machine of 10 to 12 gallons per minute capacity

Power machines are the most satisfactory where the orchard is large enough to warrant their use tho not necessarily more efficient than a good type of hand pump outfit when the latter is properly used. With any outfit the nozzle capacity must be regulated to fit the capacity of the pump. No outfit will do good work when the pump is unable to supply the liquid fast enough to maintain a good pressure. It makes little difference whether a double acting horizontal pump or an upright duplex or triplex pump is used if the capacity is large enough and it is well made; provided that plenty of power is supplied to operate it at full capacity, and that the outfit is not too heavy. However excellent in all other ways, an outfit is not dependable unless it has a good pressure regulator.

It must be remembered that efficiency in spraying is secured only by doing the work thoroly and at a time that will prevent infestation and infection. Protection by spraying is preventive rather than curative. A spray applied at the wrong time is little better than no spray. Spraying in a half-hearted way is often worse than no spray. It costs money but does no good. It is cheaper to buy an efficient machine than to "kill time tinkering" with a poor one.

SPRAY CALENDAR FOR APPLES

WHEN TO SPRAY	FOR WHAT TO SPRAY	WHAT TO USE
1. Just as the leaf buds begin to swell,—if needed. Called the <i>dormant spray</i> .	San Jose scale, oyster-shell scale, woolly aphis, and to assist in preventing the spreading of canker infection.	Coarse mist of lime sulphur, 1 gallon to 10 gallons of water, at 200 to 225 pounds pressure.
2. As soon as the blossom buds in the clusters begin to separate and turn pink. <i>Cluster-bud spray</i> .	Scab, black rot, curculio, and leaf-eating insects.	Coarse mist of Bordeaux plus arsenate of lead (3-4-2-50), or 1½ gallons of lime sulphur plus 1½ pounds arsenate of lead powder or 2 pounds arsenate of lead paste to 50 gallons of mixture, at 225 to 250 pounds pressure.
3. When two-thirds of the petals have fallen. The <i>petal-fall spray</i> .	Codling moth, curculio, scab, rust, black rot, and leaf-eating insects.	Coarse mist of lime sulphur, 1½ gallons to 50 gallons of water, plus arsenate of lead, as indicated above, at 225 to 250 pounds pressure.
4. Three weeks after the petals have fallen. <i>Three-weeks' spray</i> .	Codling moth, curculio, lesser apple worm, scab, black rot, blotch, and leaf-eating insects.	Fine mist of lime sulphur, 1½ gallons to 50 gallons of water, plus arsenate of lead as indicated above. If blotch is serious and weather will permit, use Bordeaux and arsenate of lead.
5. Five weeks after the petals fall, if blotch is serious. <i>Five-weeks' spray</i> .	Same as for <i>three-weeks' spray</i> .	Fine mist of Bordeaux (3-4-2-50). Include poison if necessary. Apply same as <i>three-weeks' spray</i> .
6. Just before second brood of codling-moth larvæ appears. <i>Second-brood spray</i> .	Second brood of codling moth, lesser apple worm, bitter rot, blotch and sooty blotch.	Fine mist of lime sulphur (1½-50) plus arsenate of lead as indicated above at 200 to 225 pounds pressure. Bordeaux is preferable if rot is present or if weather is hot and dry.
7. Just before third brood larvæ appear. <i>Third-brood spray</i> .	Third brood of codling moth, when present.	The same as for the <i>second-brood spray</i> .

Ordinarily only sprays No. 2, 3, 4, and 6 are needed in Nebraska. San Jose scale is not present in many Nebraska orchards, and blotch, while quite prevalent, is confined principally to varieties such as Missouri, Mann, Maiden Blush, Northwest Greening, and Ben Davis.

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**PORK PRODUCTION ON IRRIGATED LANDS IN
WESTERN NEBRASKA**

BY JAMES A. HOLDEN

DISTRIBUTED APRIL 10, 1917



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U. S. A.



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¹Resigned

²Detailed from Office of Dry Land Agriculture, United States Department of Agriculture, Washington, D. C.

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SUMMARY

Because of the relatively small capital and short time required to get a start in the swine industry and because of the high efficiency of hogs in utilizing certain field crops, swine production is a specially promising industry for irrigation farmers. The following statements are based on results from experiments conducted at the Scottsbluff Experiment Farm in 1912, 1913, 1914, 1915, and 1916.

In four years' experiments, including ten lots of hogs, in which alfalfa was supplemented with a 2 per cent ration of corn, an average gain of 3,191 pounds per season was made from an acre of alfalfa pasture and 7,752 pounds of corn. It required an average of 2.43 pounds of corn in addition to alfalfa pasture to produce 1 pound of pork. If the gains are valued at 7 cents a pound and corn at 60 cents a bushel, the average annual return was \$140.42 per acre of alfalfa pasture. If the corn fed is valued at 60 cents a bushel and the alfalfa pasture at \$15 an acre, the average cost of 100 pounds of gain was \$3.07. If the average yield of the alfalfa plats in the same field is assumed to represent the yield of the pastured plats, the hogs paid an equivalent of \$25.16 per ton of hay.

In two years' experiments with alfalfa pasture with and without supplemental feed, an average annual return of \$45.08 per acre was obtained where no grain was fed, \$70.20 where a 1 per cent corn ration was fed, \$128.49 where a 2 per cent corn ration was fed, \$121.96 where a 2 per cent ration of ground barley was fed, and \$168.25 where a 3 per cent corn ration was fed. An average of 644 pounds of gain per acre was secured where no supplement was used, as compared with 1,488 pounds of gain where 3,174 pounds of corn was supplemented, 3,006 pounds of gain where 7,657 pounds of corn was supplemented, 2,776 pounds of gain where 7,236 pounds of ground barley was supplemented, and 4,354 pounds of gain where 12,760 pounds of corn was supplemented. The rate of gain and the carrying capacity of the pasture increased with the quantity of grain fed. Ground barley appeared to be as good, pound for pound, as shelled corn for hogs on alfalfa pasture.

Altho the 1-acre pastures, in 1916, on which corn and ground barley were compared as supplementary feed suffered much from wind and hail storms, the results were fairly satisfactory and added strength to the previous years' data which showed that ground barley is equal to shelled corn as a hog feed.

In a mixed lot of shotes, sows, and pigs, 1,029 pounds of gain

were made from 2,316 pounds of corn and one acre of alfalfa pasture from April 29 to June 29.

Sows and pigs on alfalfa pasture, with a 2 per cent ration of grain, made an average gain of 1,516 pounds per acre of alfalfa pasture from May 1 to July 1, or a net return of \$63.11 per acre. When corn was used, the return varied from \$54.11 to \$69.97 per acre, and when barley was used the return was \$77.76 per acre.

In an experiment which covered a period of two months, where corn and alfalfa pasture was compared with corn alone in dry-lot for finishing shotes for market, one and three-quarters acres of pasture and 10,677 pounds of corn made 610 pounds more pork than the corn would have made had it been fed in dry-lot. During the first month the hogs in dry-lot made a pound gain from 4.55 pounds of corn but during the second month they were fed 5.63 pounds of corn for 1 pound of gain. For the whole period the hogs on pasture made 25.8 pounds of gain and the hogs in dry-lot 19.5 pounds of gain per 100 pounds of corn.

In four years' experiments, hogging corn without supplementary feed produced an average of 882 pounds of gain, worth \$61.74 per acre, or \$1.52 per hundredweight of the estimated yield of corn.

In two years' experiments, hogging corn without supplementary feed produced an average of 744 pounds of gain worth \$52.08 per acre, as compared with 930 pounds of gain worth \$65.10 where the hogs had access to alfalfa pasture, and 1,029 pounds of gain worth \$72.03 where the hogs were fed tankage in addition to the corn. Where no supplementary feed was used, the hogs paid \$1.34 per hundredweight for the estimated yield of corn, as compared with \$1.55 per hundredweight where the hogs had access to alfalfa pasture and \$1.50 per hundredweight where tankage was used. The use of either alfalfa or tankage resulted in more rapid and cheaper gains than were secured where no supplementary feed was used.

In a number of dry-lot feeding experiments in which corn, ground barley, sugar beets, mangels, cull potatoes, and alfalfa hay were fed in different combinations, one year's result shows that a 15-ton yield of sugar beets has the same feeding value as a 22.5-ton yield of mangels. An average of two years' experiments shows that the net profit from a 14.25-ton yield of sugar beets is the same as from a 60-bushel yield of corn when both are fed to fattening hogs. In this experiment 583 pounds of sugar beets was equivalent to 100 pounds of corn. On this basis corn at \$1.07 a hundredweight is a cheaper feed than sugar beets at \$5 a ton. In this same test the corn lot paid \$8 a ton for alfalfa hay and \$1.63 a hundredweight for corn; when the beet lots are

charged this same amount for corn and alfalfa hay, one lot paid \$5.61 and the other \$5.57 a ton for the beets fed. Results from one year's test show that ground barley supplemented with sugar beets and alfalfa hay made faster and cheaper gain than corn supplemented with the same feeds. Cull potatoes made slower but cheaper gain than sugar beets when each was fed with corn and alfalfa hay.

PORK PRODUCTION ON IRRIGATED LANDS IN WESTERN NEBRASKA¹

JAMES A. HOLDEN

INTRODUCTION

The farmer who makes a success on high-priced irrigated land must not only grow large crops but market these crops in the most advantageous way. Most crops grown in localities far removed from the large consuming centers should be marketed in condensed form, so as to reduce the cost of transportation. For example, a hundred pounds of butter can be shipped to market much more cheaply than the hay and grain required to produce this butter. The farmer should take advantage of this fact in organizing his operations. In addition to this saving, the manure resulting from the feeding of the crops makes it possible to produce larger crops in subsequent years.

Many of the farmers on irrigated projects are financially unable at present to secure dairy cows or to get cattle or sheep to feed. There are very few, however, who can not get into the hog business in a very short time. Less capital and time are required in getting into the hog business than in any other live stock industry. With \$25 with which to buy small pigs and with very little grain and good alfalfa pasture, the farmer can get well started in the hog business in two years. Horses and cattle increase annually 60 to 80 per cent, sheep a little more than 100 per cent, while hogs should increase 600 per cent or better. The buildings necessary for the housing of hogs are also relatively inexpensive. The hog is a very economical feeder. It takes less feed to produce a pound of pork than any other kind of meat produced on the farm. The hog has the ability quickly to transform the products of the farm into a readily marketable commodity.

In the irrigated sections of the West, where alfalfa, sugar beets, and potatoes are the principal crops and where grain crops occupy a secondary position, the farmer needs information on the following points: (1) The practicability of using alfalfa as

¹A detailed report of the alfalfa pasturing and corn hogging experiments that were conducted previous to 1916 is given in Bulletin No. 488 of the United States Department of Agriculture, which will be sent to anyone upon application. These experiments were conducted on the Scottsbluff Experiment Farm. This experiment farm is maintained coöperatively by the University of Nebraska and the United States Department of Agriculture. The primary object of these experiments has been to determine the most efficient methods of utilizing in hog production certain of the crops grown on irrigated lands of the western part of the state. The author desires to acknowledge the assistance given him by Henry Sullivan and A. C. Moore in carrying out the details of the experiments.

hog pasture; (2) the value of different quantities of grain when fed to hogs on alfalfa pasture; (3) the comparative values of corn and ground barley when fed to hogs on alfalfa pasture; (4) the practicability of hogging down corn; and (5) to what extent can beets, mangels, or cull potatoes replace grain to an advantage in the winter finishing of hogs for market. Some information on these points has been secured from experiments which have been conducted at the Scottsbluff Experiment Farm on the North Platte Reclamation Project during the five years 1912 to 1916 inclusive.¹

GENERAL DESCRIPTION OF THE METHODS FOLLOWED

It has been the aim of this bulletin to use average prices and to report sufficient fundamental data to enable anyone to apply different prices to the results. The prices used, except where otherwise stated, are as follows: Gains made by hogs, \$7 per hundredweight; corn, \$1.07 per hundredweight (or 60 cents a bushel); ground barley, \$1 per hundredweight; alfalfa hay, \$8 a ton; tankage, \$64 a ton; sugar beets, \$5 a ton; mangels, \$3 a ton; and cull potatoes, \$5 a ton. The data, which usually have been calculated to an acre basis, show the results that were obtained from quarter-acre plats of alfalfa pasture, which, if cut for hay, would have yielded from 4 to 6 tons per acre; and in the case of corn hogged, from one-third or one-quarter-acre plats that yielded as high as 80 bushels of corn per acre. It must be remembered by farmers who attempt to follow these methods of crop utilization that the higher the yield of the crop the larger will be the returns.

The term "per cent," when referring to rations, indicates the number of pounds fed daily per 100 pounds of live weight.

The cost of the condiments fed, sprays used, interest on investment, risk, and labor are not considered in this report.

The term "net return," as used in the following text and tables, refers to the difference between the total return and the estimated value of grain fed and is not to be taken as the net return of the land after production costs and interest charges have been deducted.

The hogs in these experiments had access to salt, slacked coal, and rock phosphate most of the time. They were also sprayed with coal-tar creosote every two or three weeks to keep them free from lice. In fact, they received the treatment that every farmer should give his hogs. Regularity in feeding, both in time and quantity of feed, clean quarters, and freedom from lice are

¹See also Bulletin No. 488 of the United States Department of Agriculture.

three very important factors that are essential to successful hog raising; and these were provided in the experiments under consideration. The data here reported are the results of tests covering one to five years. In the alfalfa pasturing experiment, two lots of hogs were used each season; and in the corn hogging experiment, with supplemental feeds, duplicate lots were used.

ALFALFA PASTURING EXPERIMENTS

The alfalfa pasturing experiments were begun in 1913 and continued in 1914, 1915, and 1916. In 1913, 1914, and 1915 quarter-acre plats were used, while in 1916 there were one-quarter-acre, three-quarter-acre, and one-acre plats. Each plat was divided into two equal parts and the hogs were changed from one to the other as the pasture became short. This allowed the alfalfa to recuperate and at the same time provided fresh, palatable feed. It was the plan to pasture the alfalfa to its full carrying capacity but not to overgraze. This made it necessary to remove some of the hogs during the latter part of the experiment, for as the season advanced and the nights became cool the alfalfa made slower growth and at the same time the hogs were increasing in size, thus requiring more feed. A few times during periods of three or four days of cloudy weather and also during the last month, when alfalfa was making little growth, the plats were perhaps slightly overpastured. As far as could be determined, however, no plat was pastured more heavily than another.

In most cases the corn was fed on the ear during the first period, and shelled corn was fed during the second period. Ear corn was fed on the ground and the shelled corn in trough. The barley was ground and fed as a thick slop. Grain was fed once a day, in the evening. It is believed that when fed grain but once a day the hogs will make more use of the pasture than when grain is fed both morning and evening, as is usually the case. When not fed until evening, the hogs become hungry and will graze during the cool hours of the evening, even after the grain is eaten. Again, if the hogs are not fed grain in the morning, they will stay out on pasture until the heat of the sun drives them to shade. The method of feeding grain once a day also saves labor.

During the pasture season two sets of hogs were used. Fall-farrowed shotes were used during the first period and spring-farrowed pigs during the second period. In 1914 this plan was not followed strictly, as it was necessary to use a few fall-farrowed pigs thruout the season, owing to the loss of spring pigs from

cholera. The reason for using two sets of hogs is that fall-farrowed pigs when fed a liberal grain ration are ready for market about July 15, and the April-farrowed pigs are not large enough to utilize the pasture much before that date.

SUMMARY OF FOUR YEARS' RESULTS WHEN SUPPLEMENTED WITH A 2 PER CENT CORN RATION

To date there are four years' results from pasturing hogs on alfalfa with a 2 per cent corn ration. In 1915 there were two lots, so that during the four years there have been ten lots in all, five in each pasturing period. The results of the four years' tests with these ten lots are summarized in table 1, in which the data have been calculated to an acre basis.

TABLE 1—Results obtained by feeding ten lots of pigs on alfalfa pasture, supplemented with approximately a 2 per cent ration of corn, at the Scottsbluff Experiment Farm in 1913, 1914, 1915, and 1916

Items of comparison	First period	Second period	Entire season
Number of lots.....	5	5	10
Total gain per acre..... Pounds	1,305	1,886	3,191
Corn fed..... do	3,613	4,139	7,752
Grain per pound of gain..... do	2.77	2.19	2.43
Gain per 100 pounds of grain..... do	36.1	45.6	41.2
Financial statement:			
Net return per acre of pasture.....	\$52.69	\$87.73	\$140.42
Cost per 100 pounds of gain (pasture at \$15 per acre).....	3.29	2.86	3.07
Equivalent paid for hay, per ton.....	22.54	27.05	25.16

¹Labor, risk, interest on investment, etc., are not here considered.

On an acre basis the five lots made an average total gain of 1,305 pounds during the first period and 1,886 pounds during the second period, or a total of 3,191 pounds for the season. During the first period the hogs were fed 3,613 pounds of corn, and during the second period 4,139 pounds, or a total of 7,752 pounds during the season. It required 2.77 pounds of corn in the first period and 2.19 pounds in the second period, in addition to the alfalfa pasture, to produce 1 pound of gain. For every 100 pounds of corn fed, the hogs made a gain of 36.1 pounds during the first period, and 45.6 pounds the second period, or an average of 41.2 pounds during the season.

With hogs at \$7 per hundredweight and corn at \$1.07 per hundredweight, the net return per acre of alfalfa pasture was

\$52.69 for the first period and \$87.73 for the second period, or a total of \$140.42 for the season. This is equal to a daily net return of 93 cents an acre for a period of 150 days. If a charge of \$5 for the first period and \$10 for the second period is made for an acre of alfalfa pasture, the feed required to produce 100 pounds of gain cost \$3.29 during the first period, \$2.86 during the second period, and \$3.07 for the season.

Alfalfa plats similar to those pastured and in the same field have each year been harvested for hay. The four-year average yield of these plats was 5.58 tons per acre or 2.35 tons for the first period and 3.23 tons for the second period of pasturing. On the basis of this yield, if it is assumed that the cost of caring for the hogs is equal to the harvesting of the hay, the hogs in the first period paid \$22.54 and in the second period \$27.05, or an average for the season of \$25.16 a ton for alfalfa hay.

SUMMARY OF TWO YEARS' RESULTS WITH VARIOUS GRAIN SUPPLEMENTS

In 1914, experiments were inaugurated to secure information regarding (1) the most economical quantity of corn to feed to hogs on alfalfa pasture, (2) the relative efficiency of 2 per cent corn and 2 per cent ground barley rations as supplements to alfalfa pasture, and (3) the carrying capacity of alfalfa pasture when no supplement is fed. This experiment was repeated on the same alfalfa plats during the summer of 1915, with the addition of one more lot fed 2 per cent corn, which was pastured on a new alfalfa plat.

The alfalfa pastured during the two seasons was seeded on April 6, 1912, hay having been harvested from the plats during the seasons of 1912 and 1913. The plat pastured for the first time during the summer of 1915 was seeded in oat stubble on August 17, 1912, and was harvested as hay during the two seasons following. The yields of the different plats during these years were very uniform. Figure 1 gives a view of the alfalfa pasture used in this experiment.

The results of the experiments in 1914 and 1915 with alfalfa pasture and various grain supplements are summarized in table 2. As two lots of hogs were used each year in each part of the test, the figures in table 2 show the average of the results secured from four lots of hogs in each instance. The figures have been calculated to an acre basis.

The results of two years' work show that hogs on alfalfa pasture without grain produced an average of 644 pounds of gain per acre. The same area of pasture, with the addition of 3,174 pounds of corn, produced 1,488 pounds of gain. Where 7,657 pounds of corn was fed, the gain was 3,006 pounds; where

7,236 pounds of ground barley was fed, the gain was 2,776 pounds; and where 12,760 pounds of corn supplemented the alfalfa pasture, the gain was 4,354 pounds per acre of pasture. With this information the farmer can apply prices that suit his own particular condition and determine the most economical quantity of grain to feed.

TABLE 2—*Results obtained by feeding hogs on alfalfa pasture, supplemented with varying quantities of grain, at the Scotts-bluff Experiment Farm in 1914 and 1915*

Items of comparison	Lot 1, no grain	Lot 2, 1 per cent corn	Lot 3, 2 per cent corn	Lot 4, 2 per cent barley	Lot 5, 3 per cent corn
Total gain per acre . . . Pounds	644	1,488	3,006	2,776	4,354
Av. daily gain, per acre do	4.1	9.6	19.3	17.9	28.0
Grain fed do		3,174	7,657	7,236	12,760
Grain per pound of gain do		2.11	2.63	2.61	2.93
Gain per 100 lbs. of grain do		47.4	38.0	38.3	34.1
¹ Financial statement:					
Net return per acre of pasture	\$45.08	\$70.20	\$128.49	\$121.96	\$168.25
Daily net return per acre of pasture	.29	.45	.83	.79	1.08
Net return for 100 pounds of grain (pasture at \$45.08 per acre)		1.86	2.16	2.06	2.03
Cost per 100 pounds of gain (pasture at \$15 per acre) . .	2.33	3.29	3.22	3.14	3.48
Equivalent paid for hay, per ton	8.16	12.71	23.25	22.10	30.48

¹Labor, risk, interest on investment, etc., are not here considered.

Two years' results show that more pasture is required when no grain is fed and that as the grain ration is increased the area of pasture required is decreased. The areas required when no grain, 1 per cent grain, 2 per cent grain, and 3 per cent grain were fed were approximately as 5, 4, 3, and 2 respectively.

For every 100 pounds of grain fed, lot 2 made 47.4 pounds of gain; lot 3, 38 pounds; lot 4, 38.3 pounds; and lot 5, 34.1 pounds. The higher the grain ration the lower the gains per unit of grain fed. Also, the lower the grain ration the more pasture was required for 100 pounds of gain.

With the prices here used, the two-year average net return per acre of alfalfa pasture was as follows: No grain lot, \$45.08; 1 per cent corn lot, \$70.20; 2 per cent corn lot, \$128.49; 2 per cent ground barley lot, \$121.96; and the 3 per cent corn

lot, \$168.25. The average daily net return per acre for 154 days ranged from 29 cents, where no grain was fed, to \$1.08, when a 3 per cent ration of corn was fed.

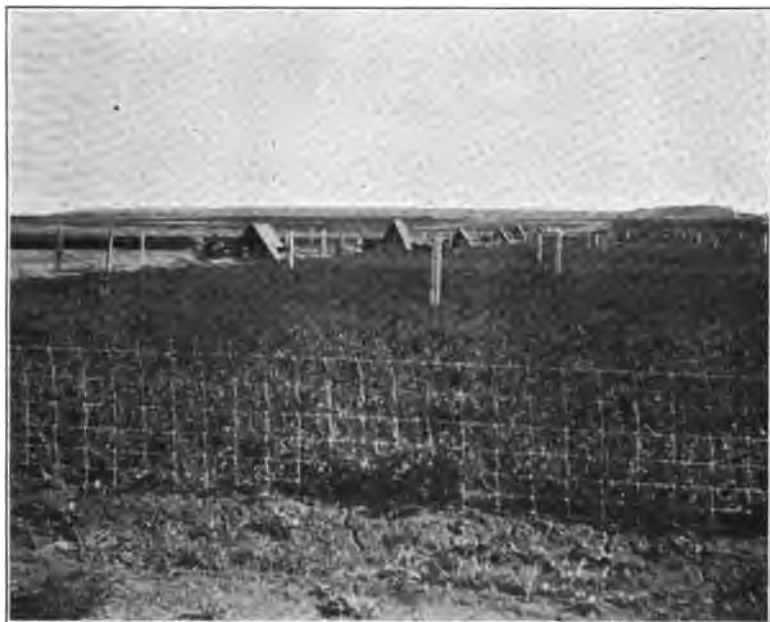


Fig. 1—The alfalfa plats used in 1914 and 1915 in the hog pasturing experiments at the Scottsbluff Experiment Farm, showing the portable houses and the method of dividing the pastures

The two-year average net return per acre of alfalfa pasture from lots 3 and 4 shows the sum of \$6.43 in favor of corn over ground barley. It will also be seen from table 2 that the corn lot was fed a little more grain than the barley lot. Higher returns would, therefore, be expected from the corn-fed lot, as the results have shown that the net returns for pasture increase with the grain ration. The difference in net returns, therefore, is not enough to warrant the statement that corn at \$1.07 per hundred-weight is cheaper feed than ground barley at \$1 per hundred-weight. The average of the two years' results, and especially the 1915 results, seem to indicate very strongly that, pound for pound, ground barley is approximately equal to corn as feed for hogs in supplementing alfalfa pasture.

The two-year average net return for alfalfa pasture was \$45.08 where no grain was fed. If the grain-fed lots are charged this amount for pasture, the net returns for each 100 pounds of grain fed were as follows: 1 per cent corn lot, \$1.86; 2 per cent corn lot, \$2.16; 2 per cent barley lot, \$2.06; and the 3 per cent corn lot, \$2.03. It appears from this that 2 pounds of corn per day for each 100 pounds of live weight is the most satisfactory ration of corn for hogs on alfalfa pasture in order to get the highest return from both the corn and the alfalfa pasture. This is true



Fig. 2—Representative hogs from the lots fed varying grain supplements on alfalfa pasture at the close of the second period in 1914. From left to right: No grain, 1 per cent corn, 2 per cent corn, and 3 per cent corn

when the feeder can get only a limited amount of corn; but when an abundant supply of corn is available at not more than \$1.07 per hundredweight, it may be desirable to feed about 3 pounds of corn to each 100 pounds of live weight. Hogs fed a 3 per cent ration of corn will make a faster growth than those fed a 2 per cent ration and hence will be ready for the market earlier. As a saving of time lessens risk and also saves interest on investment, this is a factor to be considered. Figure 2 shows a repre-

sentative hog from the lot getting no grain, and one each from lots getting 1 per cent, 2 per cent, and 3 per cent of corn in 1914.

When a charge of \$15 per acre is made for the alfalfa pasture, the total cost per 100 pounds of gain was as follows: No grain lot, \$2.33; 1 per cent corn lot, \$3.29; 2 per cent corn lot, \$3.22; 2 per cent barley lot, \$3.14; and the 3 per cent corn lot, \$3.48. The no grain lot made gains for \$1.15 per hundredweight less than the 3 per cent corn lot did. It might appear from this that to pasture hogs on alfalfa without grain is the best practice; but this is not generally true, because of the much smaller returns of pork per acre.

Perhaps the most impressive thing shown in table 2 is the amount paid for hay and its very rapid increase with the increase in the grain rations. The 2-year average yield of alfalfa hay from the check plats was 5.52 tons per acre. On this basis and assuming that the care of the hogs is equal to the cost of harvesting the hay, the no grain lot paid an equivalent of \$8.16; the 1 per cent grain lot paid \$12.71; the 2 per cent grain lots, an average of \$22.67; and the 3 per cent grain lot, \$30.48 a ton for alfalfa.

It seems certain that it will pay the farmer to feed hogs on alfalfa pasture at least 2 pounds of corn daily per 100 pounds of live weight. By so doing, not only will he get a higher return from his alfalfa, but he may expect also to make a profit on the corn fed. According to these results, it requires less capital for the same net return where grain is fed than where no grain is fed. When a 3 per cent corn ration is fed with alfalfa pasture, 1 acre will produce as much pork as 6.5 acres of alfalfa without grain, or a saving of 5.5 acres of land. Again, when fed a 3 per cent corn ration with alfalfa pasture, 52 pigs will make as much pork as 156 pigs on alfalfa pasture alone.

ONE-ACRE PASTURES SUPPLEMENTED WITH CORN AND GROUND BARLEY

During the summer of 1916, corn and ground barley, as supplements to alfalfa pasture, were compared on 1-acre plats. At the beginning of each period about a 2 per cent grain ration was fed and this was gradually increased to about a 3 per cent grain ration at the end of the period. During the spring and early summer these pasture plats suffered many disadvantages. The growth was retarded by the cold, backward spring. This was followed by severe windstorms which did much damage to the pasture plats by drifting soil onto them from an adjacent oat field. Particularly was this true of the plat where barley was fed. This plat was so badly damaged that the hogs were kept in dry-lot for six days to give the alfalfa a chance to recuper-

ate. Again, on June 12 the pasture was so badly damaged by hail that each lot was kept in dry-lot one week to give the alfalfa a chance to start anew. The hogs are charged with the grain fed while in dry-lot.

The pasturing season began April 29 and the first period ended June 29. During this period there were 20 shotes in the corn lot with a total initial weight of 1,456 pounds and a final weight of 2,628 pounds, or a gain of 1,147 pounds. This lot was fed 2,834 pounds of corn, or 2.47 pounds of corn for 1 pound of gain. For 100 pounds of corn fed, these shotes made 40.5 pounds of gain. The difference between the cost of the corn fed and the value of the gain made was \$49.97. At the beginning of this period the barley lot had 20 shotes, but on May 27 one became sick and was removed. Its final weight was less than its initial weight. The initial weight of the other 19 shotes was 1,456 pounds and their final weight was 2,419 pounds, or 942 pounds of gain. They were fed 2,897 pounds of ground barley, which was 3 pounds of barley for 1 pound of gain, or 33.3 pounds of gain for 100 pounds of barley. When this lot was charged \$1 per hundredweight for the barley fed, the difference between this cost and the value of the gains was \$38.45.

The second period began June 30. There were 40 spring pigs in each lot, 20 of which were removed September 11 and the other 20 October 5. During the last week or ten days, the pastures were rather short. The total initial weight of the corn lot was 1,192 pounds, and the final weight was 3,187. To produce the 1,995 pounds of gain the shotes were fed, in addition to the 1 acre of alfalfa pasture, 5,774 pounds of corn, or 2.89 pounds of corn for 1 pound of gain. For 100 pounds of corn fed, this lot produced 34.6 pounds of gain. This lot gave a net return of \$77.87 for the alfalfa pasture. The total initial and final weights of the barley lot were 1,191 and 2,929 pounds, respectively, or a gain of 1,738 pounds. This lot was fed 2.8 pounds of ground barley for 1 pound gain, or a total of 5,000 pounds. A gain of 35.7 pounds was made for each 100 pounds of ground barley fed. The barley lot gave a net return of \$71.66 for the alfalfa pasture.

A summary of the results of the two periods of 1916 is given in table 3.

TABLE 3—Results secured by grazing hogs on one-acre alfalfa pastures supplemented by corn and ground barley at the Scotts-bluff Experiment Farm in 1916

Items of comparison	1-acre pasture, corn	1-acre pasture, ground barley
Total gain.....Pounds	3,142	2,701
Average daily gain.....do	20.4	17.5
Grain fed.....do	8,609	7,897
Grain per pound of gain.....do	2.74	2.92
Gain per 100 pounds of grain.....do	36.5	34.2
¹ Financial statement:		
Net return for pasture.....	\$127.84	\$110.11
Daily net return for pasture.....	.83	.72
Cost per 100 pounds of gain (pasture at \$15 per acre)...	3.40	3.47
Equivalent paid for hay, per ton.....	22.15	19.05

¹Labor, risk, interest on investment, etc., are not here considered.

For the entire season of 1916, as shown in table 3, the gain from the corn lot was 3,142 pounds, and from the barley lot 2,701 pounds. The corn lot consumed 2.74 pounds of corn, and the barley lot 2.92 pounds of ground barley, for each pound of gain made. A gain of 36.5 pounds in the corn lot and 34.2 pounds in the barley lot was made from each 100 pounds of grain fed. When the gains made are figured at \$7 per hundred-weight and the lots charged \$1.07 per hundredweight for corn and \$1 for ground barley, the net returns for the 1-acre alfalfa pastures were \$127.84 where corn was fed and \$110.11 where barley was fed.

In comparing these two lots it must be remembered that the pasture of the barley lot was more severely damaged by the windstorms and that one of the shotes in this lot became sick 28 days after the experiment began, and was removed. In the first period the corn lot was fed 2.47 pounds and the barley lot 3 pounds of grain for 1 pound of gain. During the second period, however, which was more uniform for both lots, the barley lot was fed .09 pound of grain less than the corn lot for 1 pound gain. The results from the second period check very closely with the results obtained in 1914 and 1915, which showed that ground barley, pound for pound, was practically equal to corn as a hog feed.

A MIXED LOT OF HOGS ON AN ACRE PASTURE SUPPLEMENTED WITH A 2 PER CENT CORN RATION

This was a mixed lot of hogs. There were 15 shoters (888 pounds), 2 sows (391 pounds), and 12 pigs (122 pounds), with a combined initial weight of 1,401 pounds. The experiment began on April 29 and continued 60 days. The lot made a total gain of 1,029 pounds, the final weight being (shoters, 1,658; sows, 355; and pigs, 417) 2,430 pounds. In addition to the one acre of alfalfa pasture, this lot was fed 2,316 pounds of corn, or 2.25 pounds for 1 pound of gain. When charged \$1.07 per hundred-weight for corn, this lot gave a daily net return of 79 cents for the alfalfa pasture.

SOWS AND LITTERS ON PASTURE WITH A GRAIN SUPPLEMENT

The following is a brief discussion of the results obtained by pasturing sows and their litters on alfalfa pasture, supplemented with about a 2 per cent grain ration. Corn was fed in each case, with the exception of one lot in 1915 which was fed ground barley. The experiments began in the spring as soon as the pasture would stand grazing and continued 60 days. One lot was used in 1914, three lots in 1915, and one in 1916. In 1914 and 1915 quarter-acre pastures were used, while in 1916 the pasture was three-fourths acre. These pastures were grazed at the rate of eight sows and their litters per acre during the first month and a half. At this date the pigs were old enough to wean; and to prevent overpasturing the plats, some or all of the sows were removed. There are two ways of looking at the results of these experiments. One is to charge the pigs with only the feed, and the other is to charge the pigs with both feed and the loss in weight of the sows. The second method is used here.

The data obtained by pasturing sows and pigs on alfalfa pasture and about a 2 per cent grain ration, calculated to an acre basis, are given in table 4.

As shown in this table, the net returns were higher in 1915 than in either 1914 or 1916. The average of the five lots shows that it required 2.6 pounds of grain with alfalfa pasture to produce 1 pound of gain, or for every 100 pounds of grain fed the sows and pigs gained 38.4 pounds. The average net return per acre of alfalfa pasture for 60 days was \$63.11, or a daily net return of \$1.05. The lowest net return for the pasture was \$54.11 and the highest \$77.76. This highest net return was obtained from the lot fed ground barley.

If the sows and pigs are charged \$7 per acre for 60 days' use of alfalfa pasture, \$1.07 per hundredweight for corn, and \$1 per hundredweight for barley, each 100 pounds of gain cost on

an average \$3.24. The gains on the 1914 lot cost \$3.83 per hundredweight, while the gains on the barley lot in 1915 cost only \$2.76.

TABLE 4—Results obtained by feeding sows and their litters on alfalfa pasture, supplemented with a 2 per cent ration of grain, at the Scottsbluff Experiment Farm in 1914, 1915, and 1916

Items of comparison	1915				Average of five lots
	1914 2% corn	2% barley	2% corn	1916 2% corn	
Number of sows and litters	8	8	8	8	8
Average number of pigs per litter	7	8.5	7.5	5.7	7.23
Total gain..... Pounds	1,492	1,672	1,592	1,286	1,516
Average daily gain per lot do	24.9	27.9	26.5	25.7	25.3
Total grain fed..... do	4,704	3,928	4,392	3,152	3,942
Grain per pound of gain.. do	3.15	2.35	2.76	2.28	2.60
Gain per 100 lbs. of grain do	31.7	42.5	36.2	40.5	38.4
Financial statement:					
Net return per acre of pasture	\$54.11	\$77.76	\$65.52	\$57.20	\$63.11
Daily net return per acre of pasture.....	.90	1.30	1.09	.95	1.05
Cost per 100 pounds of gain (pasture at \$7 per acre)....	3.83	2.76	3.32	3.36	3.24
Equivalent paid for hay, per ton.....	19.02	37.74	31.80	21.18	28.74

¹Labor, risk, interest on investment, etc., are not here considered.

The average yield of similar plats of alfalfa during these pasturing periods was 2.23 tons per acre. If it is assumed that the pastured plats would have yielded the same, the five lots paid an average of \$28.74 a ton for alfalfa hay and the hogs did the harvesting themselves. Moreover, by pasturing the alfalfa

it may be assumed that the fertility of the soil was somewhat increased.



Fig. 3—Sows and pigs on alfalfa pasture in 1914. The little pigs increased in weight from an average of 11.7 pounds to 45.4 pounds in 60 days, almost 400 per cent

CORN AND PASTURE VERSUS CORN IN DRY-LOT FOR FINISHING SHOTES

In this experiment corn and alfalfa pasture was compared with corn in dry-lot for finishing shotes for market. The experiment began on July 7, 1916, and ended September 8, a period of 63 days. The shotes used in this experiment had been on alfalfa pasture and about a 2 per cent ration of grain since April 29. Four lots were used. Two lots, one with 16 shotes and the other with 12 shotes, were grazed on a 1-acre and a three-fourths acre pasture, respectively. Corresponding lots were fed corn in dry-lot. The shotes in dry-lot were given all the corn they would clean up, while the shotes on pasture were fed a limited amount of corn during the first 30 days but during the last 33 days were fed all they would eat. The shotes on pasture had

an abundance of young alfalfa all the time; in fact the pasture would have carried perhaps a fourth more hogs.

The shotes in each lot were weighed at the end of the first month and again at the end of the experiment. The amount of grain fed each lot was also kept separate for each period. If the corn is credited with the value of the gains made, the two dry-lots paid \$1.56 and \$1.51 during the first period, but only \$1.21 and \$1.28 respectively during the second period, for each 100 pounds of corn fed. This difference, no doubt, was due to the fact that the hogs had been on alfalfa pasture with about a 2 per cent grain ration for two months previous to this experiment and were in prime condition to make gains when put on a full grain ration, but after the first 30 days, the residual effect of the alfalfa, so to speak, had more or less disappeared.

The results for the whole period are summarized in table 5. The shotes used in lots 2 and 4 were smaller than those used in the other two lots,—they were what might be called culls but not runty. Lots 1 and 3 and lots 2 and 4, respectively, are comparable.

TABLE 5—*Results obtained from an experiment comparing corn and alfalfa pasture with corn in dry-lot at the Scottsbluff Experiment Farm in 1916*

Items of comparison	Corn and pasture		Corn in dry-lot	
	1-acre lot 1	$\frac{1}{2}$ -acre lot 2	lot 3	lot 4
Number of shotes	16	12	16	12
Average initial weight..... Pounds	149	119	143	123
Average final weight..... do	239	208	218	206
Total gain..... do	1,432	1,065	1,203	999
Total corn fed..... do	5,556	4,121	6,192	5,108
Corn per pound of gain.... do	3.88	3.87	5.15	5.11
Gain per 100 pounds of corn do	25.8	25.9	19.4	19.6
¹ Financial statement:				
Value of gains (at 7c per pound)...	\$100.24	\$74.55	\$84.21	\$69.93
Equivalent paid for 100 pounds of corn when fed in dry-lot....			1.36	1.37
Net return per acre of alfalfa pasture (corn at \$1.36 and \$1.37).....	24.68	24.13		
Net return per acre of alfalfa pasture (corn at \$1.07).....	40.80	40.58		
Cost per 100 pounds of gain (corn \$1.07, pasture \$7 per acre)....	4.62	4.72	5.51	5.47

¹Labor, risk, interest on investment, etc., are not here considered.

The pasture lots were fed an average of 3.29 and the dry-lots an average of 4.55 pounds of corn during the first month and 4.22 and 5.64 pounds, respectively, during the second month for each pound of gain made. For the whole period the pasture lots made an average of 25.8 pounds of gain, and the dry-lots an average of 19.5 pounds of gain, for each 100 pounds of corn fed. Had the corn that was fed on the pasture lots been fed in dry-lot it would have produced only 1,887 pounds of gain instead of 2,497 pounds. The one and three-quarter acres of alfalfa pasture, therefore, produced 610 pounds of gain, which, with hogs at \$7 per hundredweight, is worth \$42.70. This is equivalent to \$24.21 per acre for alfalfa pasture from July 7 to September 8. Had the hogs in dry-lot been on pasture they would have made the same amount of gains with 2,762 pounds less corn and the gains would have been faster.

As shown in table 5, lot 3 paid \$1.36 and lot 4, \$1.37 per hundredweight of corn. If lots 1 and 2 are charged \$1.36 and \$1.37, respectively, for the corn fed, lot 1 gave a net return of \$24.68 and lot 2, \$24.13 per acre for alfalfa pasture for 63 days. When charged \$7 an acre for two months' pasturing and \$1.07 per hundredweight for corn, each 100 pounds of gain cost an average of \$4.67 in the pasture lots and \$5.49 in the dry-lots.

HOGGING CORN

The experiments which have been conducted with different methods of hogging corn fall into two classes, (1) those in which no supplement was fed with the corn and (2) those in which the hogs were provided with some nitrogenous feeds while they were in the cornfield. Experiments in which no supplements were used have been conducted for five years and the others for two years.

SUMMARY OF FOUR YEARS' RESULTS ON CORN WITHOUT SUPPLEMENTARY FEED

Each year in the irrigated crop-rotation field, a quarter-acre plot of corn in a 6-year rotation is fenced and the hogs are turned into it to harvest the crop. This experiment began in 1912 and has been continued each year. The hogs are turned into the corn when it is well "dented," usually about September 10. As no supplementary feed is supplied and as the weeds and volunteer alfalfa are kept down, the gains secured are made from corn alone. Each year since 1912 the corn has been grown on land which had produced alfalfa the previous year. This explains the difference in yields, as will be indicated later.

The results of the four years' tests, computed to an acre basis, are given in table 6. These results are not strictly com-

parable, as there were two varying factors. The average initial weight of the hogs varied from 117 pounds in 1912 to 63 pounds in 1914, and the number of days that the hogs were on the corn varied from 16 in 1912 to 49 in 1914. Small shoters will make more gain than larger hogs from a given quantity of feed. Hogs that have just been taken from alfalfa pasture will make very good gains for a short period on corn alone, but when fed corn alone for a long period the gains are not so good. In other words, 100 pounds of corn will make more gain on hogs the first week after the hogs are taken off alfalfa pasture than the same amount of corn will when fed to hogs that have been on corn alone for several weeks. As will be seen from table 6, these two variable factors were in direct opposition to each other; that is, the larger the hogs the shorter the feeding period. As the corn crop in 1915 was seriously affected by hail, the results of that year are not included in the average shown in table 6, but they are shown in the last column of the table as a matter of record.

TABLE 6—*Results of hogging corn without supplementary feed at the Scottsbluff Experiment Farm from 1912 to 1916, inclusive*

Items of comparison	1912	1913	1914	1916	4-year average	1915
Number of hogs.....	28	24	24	20	24	12
Number of days.....	16	28	49	23	36	19
Average initial weight, Pounds	117	91	63	94	91	75
Total gain per acre.... do	628	1,012	1,048	840	882	212
Gain per 100 lbs. of corn do	20.0	21.8	22.6	22.4	21.7	14.5
¹ Financial statement:						
Value of gains per acre.....	\$43.96	\$70.84	\$73.36	\$58.80	\$61.74	\$14.84
Returns per 100 pounds of corn.....	1.38	1.53	1.60	1.56	1.52	1.00
Cost per 100 pounds of gain (corn at \$1.07 per hundredweight).....	5.36	4.81	4.67	4.78	4.90	7.43

¹Labor, risk, interest on investment, etc., are not here considered.

A short hogging period is objectional from an experimental standpoint because there are more chances of error. For example, if the hogs are gaunt at either the initial or the final weighing, 20 hogs on a corn plat for 1 week will give a larger error than 2 hogs on the same plat for 10 weeks. The mean weight of three consecutive days' weighings will not entirely eliminate this error, especially if the hogs are left on the corn plat too long and are gaunt at the final weighing. Just how much each of these factors influenced the results shown in table 6 is uncertain. There is

little doubt but that the low returns per bushel of corn in 1912 were due to the fact that a larger sow was in the lot. The low total gains and net returns per acre in 1912, however, were due largely to the low yield of corn, it having been estimated at 56.1 bushels per acre, as compared with 82.6, 81.9, and 66.9 bushels respectively for 1913, 1914, and 1916. In computing the cost of 100 pounds of gain, a charge of \$1.07 per hundredweight was made for the corn. The results show that this method of utilizing corn has much to recommend it.

**SUMMARY OF TWO YEARS' RESULTS WITH DUPLICATE LOTS ON CORN WITH
SUPPLEMENTARY FEED**

To secure information regarding the value of tankage and of alfalfa pasture as supplements to corn when hogged off, an experiment was conducted in duplicate in 1914 and 1915. Six lots of hogs were used each year, as follows: Lots 1 and 2 hogged corn alone; lots 3 and 4 hogged corn and had access to an alfalfa field; and lots 5 and 6 hogged corn and had what tankage they would eat. The shotest used in this experiment had been in the alfalfa pasturing experiment and were very uniform in size, as will be seen from the weights in table 7.

Each year the yield of each plat was estimated by counting all the stalks of corn and harvesting systematically the corn from 100 stalks; that is to say, if a plat had a total of 3,400 stalks, the corn was harvested from every thirty-fourth stalk. The harvested corn was dried, weighed, and returned to the plat to be eaten by the hogs. The total weight was divided by 100, to determine the average yield per stalk harvested. This average weight was then multiplied by the total number of stalks on the plat in order to determine the yield.

As the low-yielding plats became cleaned up, weighed quantities of corn were added, so that all the hogs would be kept on feed the same length of time. Enough corn was added as became necessary so that the hogs had corn before them all the time. When the last lot had cleaned up its plat the experiment was closed.

A summary of the two years' results of these experiments, calculated to an acre basis, is given in table 7.

TABLE 7—Results of hogging corn, with supplementary feed, at the Scottsbluff Experiment Farm in 1914 and 1915

Items of comparison	Corn only	Corn and alfalfa pasture	Corn and tankage
Number of lots.....	4	4	4
Number of hogs per acre in each test.....	9	9	9
Number of days.....	66	66	66
Average initial weight per hog..... Pounds	81.7	81.7	81.0
Average final weight per hog..... do	164.4	185.0	195.3
Average daily gain per hog..... do	1.25	1.57	1.73
Total gain per acre..... do	744	930	1,029
Corn consumed (estimated yield plus corn added)..... do	3,900	4,149	4,161
¹ Financial statement:			
Value of gain (at 7c per pound).....	\$52.08	\$65.10	\$72.03
Cost of tankage (300 pounds, at \$3.20).....			9.60
Charged for alfalfa pasture.....		1.00	
Net returns per 100 pounds of corn.....	1.34	1.55	1.50
Cost per 100 pounds of gain (corn \$1.07)...	5.61	4.88	5.26

¹Labor, risk, interest on investment, etc., are not here considered.

The data given in table 7 are the averages of four lots in each case and are calculated to an acre basis. The hogs were on the experiment 77 days in 1914 and 55 days in 1915, or an average for the two seasons of 66 days. The average initial weight of the shotes in the different lots was 81 pounds, and the average final weight was 164.4 pounds for the corn-alone lot, 185 pounds for the pasture lot, and 195.3 pounds for the tankage lot, or 1.25, 1.57, and 1.73 pounds of daily gains, respectively. The tankage lot made 38 per cent faster gains than the corn-alone lot and 10 per cent faster than the pasture lot. The total gain, on an acre basis, was 744 pounds where the hogs received only corn, 930 pounds where they had access to alfalfa pasture, and 1,029 pounds when fed 300 pounds of tankage in connection with the corn. The net returns per 100 pounds of corn consumed were \$1.34 where corn was fed alone, \$1.55 where the hogs had access to alfalfa pasture, and \$1.50 when they were fed tankage. A 100-pound gain cost \$5.61 in the corn lot, \$4.88 in the pasture lot, and \$5.26 in the tankage lot.

From the results of these tests it appears that it would be better to buy tankage at \$3.20 per hundredweight and feed it to hogs in connection with hogged-off corn than not to supplement the corn, but when the hogs can have access to alfalfa pasture it is doubtful whether it would pay to feed tankage.

The chief advantage of hogging corn is that the farmer is spared the expense of harvesting the crop, hauling the manure back to the land, and feeding the corn to the hogs. A disadvantage is the cost of fencing. It seems certain that hogs will make as many pounds of gain from a bushel of corn in the field as they will if the corn is harvested and fed in dry-lot. The question for the farmer to decide, then, is whether it is cheaper to harvest the crop and feed the hogs in a dry-lot or to fence the corn and let the hogs themselves harvest it.

DRY-LOT FEEDING EXPERIMENTS

In the irrigated districts where potatoes and sugar beets are two of the principal crops, it is important to know the feeding value of cull potatoes and also to know whether it pays to feed sugar beets to fattening hogs. The latter is particularly important to farmers whose farms are far removed from the railroads so that delivering beets is expensive. It is also important to know the relative feeding value of sugar beets and mangels. To secure information on these points, experiments were conducted at the Scottsbluff Experiment Farm during the fall of 1912, 1914, and 1915.

CORN, SUGAR BEETS, AND MANGELS

The hogs used in this experiment were very good, thrifty shotes which had been on alfalfa pasture and about a 2 per cent grain ration during the summer. There were 26 shotes in all, divided into three lots, as follows: 8 in lot 1, which were fed corn only; 9 in lot 2, fed corn and sugar beets; and 9 in lot 3, fed corn and mangels. Each lot was fed all it would clean up twice daily. Beets and mangels were fed about one hour before the corn was fed. Ear corn was used but when referred to in the discussion is in terms of shelled corn on the basis of 22 per cent cob.

The average initial weight of these shotes was 105 pounds. The average daily gain per shote was 2.09 pounds in lot 1; 2.26 pounds in lot 2; and 2.20 pounds in lot 3. These are exceptionally fast gains. The experiment was conducted only 24 days, which is too short a time to show any very reliable results. Altho these results are not to be taken as conclusive, it is thought that they are of some value, particularly as indicating the relative feeding value of sugar beets and mangels. Lot 1 made 402 pounds of gain, lot 2 made 448 pounds, and lot 3 made 476 pounds. Lot 1 was fed 1,691 pounds of corn, and lots 2 and 3 were fed 1,790 pounds of sugar beets and 2,400 pounds of mangels

respectively, each receiving 1,590 pounds of corn in addition. For each 100 pounds of gain lot 1 was fed 421 pounds of corn; lot 2, 326 pounds of corn and 367 pounds of sugar beets; and lot 3, 334 pounds of corn and 504 pounds of mangels.

If the hogs are charged \$1.07 per hundredweight for corn, \$5 per ton for sugar beets, and \$3 per ton for mangels, each 100 pounds of gain cost \$4.51 in lot 1, \$4.41 in lot 2, and \$4.33 in lot 3. Lot 1 made gains enough to pay \$1.66 per hundredweight for the corn consumed. When lots 2 and 3 are charged this same price for corn, lot 2 paid \$8.61 a ton for sugar beets, and lot 3 paid \$5.77 a ton for mangels. On this basis, if sugar beets are worth \$5 a ton, mangels are worth \$3.55 a ton; or, in terms of yield, a 15-ton yield of sugar beets has the same feeding value as a 22.5-ton yield of mangels. If lot 2 is charged \$5 per ton of sugar beets and lot 3, \$3 per ton of mangels, they each paid \$1.86 per hundredweight for the corn fed.

CORN, ALFALFA HAY, AND SUGAR BEETS

EXPERIMENTS IN 1914

In the fall of 1914 another experiment, to determine the feeding value of sugar beets when fed with varying amounts of corn and alfalfa hay in racks, was inaugurated. The experiment covered 60 days. The eighteen hogs, which were divided into lots of six hogs each, were fairly good shoters, having been used during the summer in the alfalfa pasturing work. Each lot was given all the fourth-cutting alfalfa hay it would eat. In addition to this, lot 1 was fed a 4 per cent ration of corn; lot 2, a 3 per cent corn ration plus sugar beets; and lot 3, a 2 per cent corn ration plus sugar beets. Lots 2 and 3 were fed all the sugar beets they would clean up.

The total initial weight of lot 1 was 798 pounds and the final weight was 1,333 pounds. This lot made 535 pounds of gain from 2,050 pounds of corn and 344 pounds of alfalfa hay,—or, 383 pounds of corn and 64 pounds of hay per 100 pounds of gain, which cost \$4.35. In lot 2 the initial weight of the hogs was 795 pounds and their final weight 1,318, or a gain of 523 pounds. This lot was fed 1,490 pounds of corn, 3,380 pounds of sugar beets, and 250 pounds of hay. To produce 100 pounds of gain this lot was fed 285 pounds of corn, 646 pounds of beets, and 48 pounds of hay, at a cost of \$4.85. The hogs in lot 3 weighed 797 pounds when the test began and 1,274 pounds when it closed. To produce this 477 pounds of gain, the hogs were fed 1,025 pounds of corn, 5,530 pounds of beets, and 310 pounds of hay,—or 215 pounds of corn, 1,150 pounds of beets, and 65 pounds of hay, at a cost of \$5.41, for each 100 pounds of gain.

EXPERIMENTS IN 1915 WITH THE ADDITION OF CULL POTATOES AND GROUND BARLEY

The 1914 corn-hay-beet experiment was duplicated during the fall of 1915. Substantially the same methods were followed each year. In addition to these three lots, two more lots were used, in which ground barley replaced corn in one case and cull potatoes replaced sugar beets in the other. There were seven shots in each lot. The feeding period covered 72 days.

Lot 1 made 415 pounds of gain and was fed 1,818 pounds of corn and 506 pounds of hay, or 438 and 122 pounds, respectively, per 100 pounds of gain. Lot 2, which was fed 1,336 pounds of corn, 4,661 pounds of beets, and 489 pounds of hay, made 513 pounds of gain, or 100 pounds of gain from 260 pounds of corn, 908 pounds of beets, and 104 pounds of hay. In lot 3 the hogs made 486 pounds of gain from 1,013 pounds of corn, 5,689 pounds of beets, and 480 pounds of hay, which is 208 pounds of corn, 1,170 pounds of beets, and 100 pounds of hay for each 100 pounds of gain. In lot 4 ground barley was substituted for corn; otherwise this lot was similar to lot 2. Lot 4 was fed 1,224 pounds of ground barley, 5,313 pounds of beets, and 364 pounds of hay, and produced 593 pounds of gain. This lot was fed 205 pounds of barley, 896 pounds of beets, and 61 pounds of hay for 100 pounds of gain, or 55 pounds of grain, 12 pounds of beets, and 43 pounds of hay less than lot 2 for the same gain. The only difference between lot 5 and lot 2 was that cull potatoes were used in lot 5 instead of sugar beets. Lot 5 made 466 pounds of gain and was fed 1,440 pounds of corn, 2,220 pounds of cull potatoes, and 486 pounds of hay. For 100 pounds of gain this lot was fed 309 pounds of corn, 476 pounds of potatoes, and 104 pounds of hay.

Only the relative results from lots 1, 2, and 3 will be discussed here; the detailed results will be discussed under table 8, which is the summary of two years' results. The barley and potato lots have each been run only one season. The results are not, therefore, as conclusive as the results from two or more tests would be. It is thought, however, that the results at hand are of enough value to warrant their publication in brief.

Of the five feeding lots on experiment in 1915, the barley lot made the fastest and cheapest gains, while the potato lot was second in cheapness and next to the lowest in rate of gain. When the hogs are charged \$5 a ton for beets and potatoes and \$8 per ton for alfalfa hay, the barley lot paid \$2.18 per hundredweight for ground barley and the potato lot paid \$1.75 per hundredweight for corn. Lot 1, which was fed a 4 per cent corn ration and alfalfa hay, paid \$1.49 per hundredweight for corn when

charged \$8 per ton for hay. If the barley and potato lots are charged these same prices for the grain and hay, they still paid \$8.62 and \$8.31 a ton respectively for beets and potatoes.

The results of this test again indicate very strongly that ground barley has as high feeding value as corn. With the results from this test and also from the alfalfa pasturing experiments where ground barley has been compared with corn, it seems safe to say that ground barley is equal to corn as a hog feed. It must be remembered, however, that in all these tests the barley was ground.

By comparing the potato lot with lot 1, which was fed corn and alfalfa hay, it will be seen that 476 pounds of cull potatoes replaced 129 pounds of corn and 16 pounds of hay per 100 pounds of gain. According to this, when corn is worth \$1.07 a hundred-weight and alfalfa hay \$8 a ton, cull potatoes are worth \$6.05 a ton, or 18 cents a bushel. When compared with lot 2 it will be seen that 486 pounds of potatoes and 48 pounds of corn had the same feeding value as 908 pounds of beets. In lot 2 when beets were worth \$5 a ton, corn was worth \$1.30 a hundred-weight. On this basis, if the value of the 48 pounds of corn is subtracted from the value of the 908 pounds of beets at \$5 a ton, it will be seen that 476 pounds of potatoes had a comparative feeding value of \$1.65, or \$6.90 a ton. In this test 1 ton of potatoes was equivalent to 1.36 tons of sugar beets.

It is apparent from this experiment that cull potatoes have some value as a hog feed. This is contrary to the belief of many. It is not uncommon for farmers, when there is no sale for potatoes, to let their potatoes rot in the cellar and at the same time pay out cash for corn with which to finish their hogs or to carry them thru the winter. There is no question that potatoes either with a liberal ration of grain for finishing hogs or with alfalfa hay for wintering old sows have a feeding value nearly equal to sugar beets.

SUMMARY OF TWO YEARS' RESULTS

The two years' results from lots 1, 2 and 3 are given in table 8. The results were substantially the same each year, except that the corn lot made the faster gains in 1914 and the beet lots the faster in 1915. The cost per 100 pounds of gain was higher in 1915 than in 1914. In 1914 the hogs were fed ear corn, and in 1915 they were fed shelled corn. This difference in corn may explain the difference in cost, for it is generally conceded that ear corn gives a little better results than shelled corn.

TABLE 8—Results obtained by feeding finishing hogs corn and alfalfa hay; and corn, alfalfa hay, and sugar beets at the Scotts-bluff Experiment Farm in 1914 and 1915

Items of comparison	Lot 1 4% corn, hay	Lot 2 3% corn, beets, hay	Lot 3 2% corn, beets, hay
Total gain.....Pounds	475	518	483
Corn fed.....do	1,934	1,423	1,019
Sugar beets fed.....do		4,020	5,610
Alfalfa hay fed.....do	425	418	395
Corn per 100 pounds of gain.....do	407	274	211
Beets per 100 pounds of gain.....do		774	1,161
Hay per 100 pounds of gain.....do	89	81	81
¹ Financial statement:			
Value of gains.....	\$33.25	\$36.26	\$33.81
Return per 100 pounds of corn.....	1.63	1.72	1.77
Return per ton of beets (corn at \$1.63, hay at \$8).....		5.61	5.57
Return per ton of beets (corn at \$1.07).....		9.66	7.60
Cost per 100 pounds of gain.....	4.71	5.15	5.26

¹Labor, risk, interest on investment, etc., are not here considered.

By comparing lots 1 and 2 it will be seen that lot 1 consumed 133 pounds of corn and 8 pounds of hay more than did lot 2 per 100 pounds of gain. On the other hand, lot 2 was fed 776 pounds of beets. Therefore, 133 pounds of corn and 8 pounds of hay, had the same feeding value as 776 pounds of beets. To make it simple, 583 pounds of beets replaced 100 pounds of corn. On this basis, when beets are worth \$5 a ton, corn is worth \$1.46 a hundredweight. If lot 1 is charged \$8 a ton for hay it gives a return of \$1.63 a hundredweight for corn. When lots 2 and 3 were charged \$1.63 for corn and \$8 for hay, they paid \$5.61 and \$5.57 respectively per ton for beets; but when only market prices were charged for the different feeds, lots 2 and 3 paid \$9.66 and \$7.60 a ton for beets and \$1.72 and \$1.77 a hundredweight for corn, respectively. According to these returns, lot 1 paid 48 per cent, lot 2 33 per cent, and lot 3 27 per cent more than market prices for the feed consumed. One hundred pounds of gain cost \$4.71 in lot 1, \$5.15 in lot 2, and \$5.26 in lot 3.

According to these results, corn at \$1.07 per hundredweight is a cheaper feed for finishing hogs than beets at \$5 a ton. It may seem from this that beets have no place as a feed for finishing hogs; but look at it from another viewpoint. In lot 1 it required 407 pounds of corn and 89 pounds of hay to produce 100 pounds of gain. At this rate, 1,432 pounds of corn (the

amount fed to lot 2) and 301 pounds of hay would have produced 350 pounds of gain. Lot 2 made 518 pounds of gain. The 168 pounds of gain can, therefore, be credited to the 4,020 pounds of beets and 117 pounds of hay. With hogs worth \$7 a hundred-weight, this 168 pounds of gain is worth \$11.76; from this, subtract 47 cents for the 117 pounds of hay, and it leaves a balance of \$11.29 for the 4,020 pounds of beets, or \$5.61 a ton.

It is estimated that it costs \$33.10 an acre to grow sugar beets up to, but not including, hauling, and \$8.05 for growing an acre of corn up to harvesting. On this basis, and assuming that the hauling and siloing of the beets on the farm cost the same as harvesting of the corn crop, a 14.25-ton yield of beets will give the same net return as a 60-bushel yield of corn. As the farmer in most beet-growing sections can grow \$5 beets at a large profit where he is saved the expense of hauling, it appears from these results that it would be a good practice to grow both corn and beets for finishing hogs and to feed them all the corn, beets, and hay they will clean up.

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By T. A. KIESSELBACH and J. A. RATCLIFF

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¹Resigned

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⁴Granted leave of absence

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SUMMARY

1. Oats rank third in importance of the grain crops grown in Nebraska. More than 2,000,000 acres were grown during each of the last 12 years.

2. For most parts of the State, oats are less profitable than other grain crops and are frequently grown at a loss.

3. Because of special adaptation for a cool climate, oats are more nearly commercially profitable in northeastern Nebraska.

4. Variety tests extending over a period of 15 years show conclusively that early varieties are better adapted and yield more in this State than late varieties. In a 12-year test, the average yield of three early varieties was 11.1 bushels (or 22 per cent) superior to the average yield of four late varieties. There was an average difference of 8 days in time of ripening. The best early variety, Burt, yielded 20 per cent more than the best late variety, Swedish Select.

In a 6-year test, four early varieties averaged 42 per cent greater yield than ten late varieties. There was again an 8-day difference in time of ripening. The best early variety, Burt, yielded 23 per cent more than the best late variety, Swedish Select.

Practically all oats varieties grown in the United States were compared for growth and seed production during the period 1910 to 1916. None have given promise of superiority over the group of early varieties which have been thoroly compared in the field variety tests.

5. Forty strains of Kherson oats, originating from 750 head selections, have been tested 6 years in the nursery, while 10 of these have also been grown 4 years in field plats. A white Kherson strain known as "Nebraska No. 21" was increased in 1916 for distribution among farmers. This strain averaged 9 per cent higher yield than the original Kherson in the nursery and 15 per cent higher in the field plats. In this 4-year average, the yields of Nebraska No. 21, original Kherson, Burt, and Texas Red have been respectively 61.9, 54.1, 64.5, and 62.3 bushels per acre.

6. During a 5-year period, seed of both Kherson and Swedish Select oats varieties, which had been grown for many years under irrigation in western Nebraska, yielded slightly more than un-irrigated seed grown in eastern Nebraska. This suggests that seed oats of suitable varieties grown under irrigation can be used with safety for dry land planting.

7. As an average for 12 years, the heaviest one-fourth Kherson seed oats as separated by a fanning mill has yielded 0.74

bushel better than the lightest one-fourth seed, and 0.83 bushel better than the original unselected seed.

In a similar 8-year test with American Banner oats—a late variety—the heavy seed has yielded 1.44 bushels less than the light seed. During 4 years, the original unselected seed was compared with the heavy and light selections, and for this period the heavy seed yielded 3.70 bushels less and the unselected seed 1.63 bushels less than the lightest seed.

8. When distinct grades of hand-selected large and small seeds were planted during 5 years in equal numbers at a rate normal for the large seed, the large yielded 13 per cent more than the small. However, when equal weights of seed were planted at a rate normal for the large seed, both grades yielded equally and practically the same as the original unselected seed.

9. Rate-planting tests extending over a period of 12 years indicate that there may be a rather wide range in planting rate without materially affecting the yield per acre. However, the data suggest that varieties of the Kherson type should be drilled 10 to 12 pecks per acre, while those of the Swedish Select type yield best when planted 12 pecks per acre. Somewhat lower rates are recommended for central and western Nebraska because of less favorable moisture conditions.

10. During the 15-year period, 1902 to 1916, the relative yields of oats, corn, and winter wheat have been 53, 58, and 36 bushels, respectively. During the 8-year period, 1909 to 1916, oats, corn, winter wheat, and spring wheat have yielded 52, 48, 36, and 19 bushels per acre, respectively. Calculated in pounds, these yields of oats, corn, winter wheat, and spring wheat were respectively 1664, 2576, 2160, and 1140 pounds per acre. Allowing 30 per cent for hull, the net grain yield of oats equalled 1165 pounds.

11. Profit or loss from oats growing is often determined by the cultural practices followed. The oats crop responds readily to increased soil fertility and careful seed bed preparation. Early seeding and treatment for smut are desirable.

12. In a 4-year test, 1907 to 1910, the yields from Kherson oats, Oderbrucker barley, Tennessee winter barley, and Turkey Red winter wheat have been respectively 51.2, 42.9, 29.3, and 41.2 bushels, or 1638, 2059, 1406, and 2472 pounds per acre. Allowing 30 per cent for hull in oats and 15 per cent for hull in barley, these respective grain yields were 1147, 1750, 1195, and 2472 pounds per acre. Barley is the highest-producing spring crop which may be substituted for oats.

OATS INVESTIGATIONS

T. A. KIESSELBACH AND J. A. RATCLIFF

IMPORTANCE OF THE OATS CROP

The relative importance of oats and other grain crops grown in Nebraska is shown in table 1, which is compiled from the 1916 annual report of the Nebraska State Board of Agriculture. Oats are third in importance of the grain crops—more than 2,000,000 acres having been grown during each of the past 12 years. The approximate average annual acreages of corn, wheat, oats, rye, and barley during the last 9 years have been respectively 6.5, 3.1, 2.2, 0.12, and 0.1 million acres.

The large acreage devoted to oats does not signify that this is a relatively profitable crop. The relative production and acre income for the principal grain crops grown in Nebraska are shown in tables 2 and 3. The price per bushel is the average price as given by the State Board of Agriculture during 27 years.

The yields, as compiled from the 1916 annual report of the Nebraska State Board of Agriculture, are given in table 1. The grain yields for corn, wheat, and oats have been 24.9, 16.9, and 27.0 bushels per acre as an average for the 27 years, 1890 to 1916, while the average acre incomes have been, respectively, \$10.46, \$11.66, and \$7.29. During the last 9 years, 1908 to 1916, the yields of corn, wheat, and oats have been 25.7, 17.9, and 27.6 bushels per acre, and the respective acre incomes have been \$14.70, \$16.11, and \$9.66.

In table 3 are given the yields and acre incomes for corn, wheat, and oats during the 15-year period, 1902 to 1916, for the Nebraska Experiment Station at Lincoln and for Lancaster County, the county in which the Station is located. The average yields of corn, wheat, and oats at the Station have been respectively 57.2, 36.2, and 56.0 bushels per acre, while the County yields have been 26.5, 21.3, and 23.0 bushels per acre. The average acre incomes for corn, wheat, and oats have been \$29.17, \$29.32, and \$17.92 at the Station, and \$13.52, \$17.25, and \$7.36 in the County. Altho the acre cost of growing oats is somewhat less than for wheat and corn, this lower cost will not offset the lower acre income. Hence, oats are a relatively unprofitable crop.

Acknowledgment is made to Dr. T. L. Lyon, now of Cornell University, for data secured prior to 1907 and to Prof. E. G. Montgomery, also now of Cornell University, for data secured between 1907 and 1911.

TABLE 1—*Crop production in Nebraska, 1890 to 1916*¹

Year	Corn		Wheat		Oats		Rye		Barley	
	Total area	Yield per acre	Total area	Yield per acre	Total area	Yield per acre	Total area	Yield per acre	Total area	Yield per acre
	Acres	Bushels	Acres	Bushels	Acres	Bushels	Acres	Bushels	Acres	Bushels
1890.....	4,418,382	16.0	1,000,950	15.0	1,593,289	22.0	149,040	16.6	164,719	14.4
1891.....	4,638,009	15.6	1,223,787	15.0	1,420,907	24.0	110,741	15.0	147,942	20.0
1892.....	3,931,754	16.0	1,229,665	15.0	1,170,993	24.0	36,275	15.0	118,490	20.0
1893.....	3,870,689	16.0	1,340,416	15.0	1,203,890	24.0	60,978	15.0	110,171	20.0
1894.....	4,130,346	16.0	1,173,674	15.0	1,058,459	24.0	31,441	15.0	51,630	20.0
1895.....	4,271,453	16.0	1,232,252	12.0	1,676,962	23.8	54,230	15.0	68,819	20.0
1896.....	7,962,657	37.5	1,385,043	14.0	1,794,349	19.0	71,303	15.9	62,681	19.9
1897.....	8,042,283	30.0	1,893,286	14.5	1,668,745	31.0	186,910	17.0	88,755	20.0
1898.....	7,559,746	21.0	2,114,592	16.4	1,752,182	32.1	238,438	17.2	81,541	12.9
Average....	5,419,479	20.5	1,399,296	14.7	1,482,196	24.9	104,373	15.8	99,405	18.6
1899.....	6,436,918	27.3	1,918,287	9.8	1,628,501	31.8	62,319	16.0	33,874	17.6
1900.....	6,291,050	22.8	2,322,969	16.3	1,424,948	23.5	61,073	14.2	36,267	26.0
1901.....	5,853,967	12.4	2,455,677	20.5	1,577,986	32.9	155,475	15.0	74,563	15.9
1902.....	5,516,801	32.0	2,550,767	21.0	1,638,647	37.0	483,554	7.7	78,414	25.0
1903.....	6,130,369	27.7	2,379,378	18.3	1,955,721	34.0	243,067	41.6	113,717	26.5
1904.....	6,173,984	36.8	2,024,667	15.7	2,146,324	31.1	122,565	16.6	196,844	28.0
1905.....	6,472,487	37.7	2,091,871	19.8	2,420,524	32.4	141,149	17.5	188,360	31.5
1906.....	6,840,905	35.3	2,146,033	23.2	2,442,768	32.1	82,970	17.8	109,692	28.7
1907.....	6,586,844	25.8	2,528,339	18.3	2,494,946	21.5	87,913	16.0	95,373	23.6
Average....	6,255,925	28.6	2,268,665	18.1	1,970,379	28.5	160,009	18.0	102,956	24.7

Oats Investigations

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TABLE 1—Continued. Crop production in Nebraska, 1890 to 1916.

Year	Corn		Wheat		Oats		Rye		Barley	
	Total area	Yield per acre	Total area	Yield per acre	Total area	Yield per acre	Total area	Yield per acre	Total area	Yield per acre
1908.....	Acres 6,339,019	Bushels 28.2	Acres 2,545,610	Bushels 17.2	Acres 2,353,839	Bushels 23.9	Acres 88,614	Bushels 14.3	Acres 95,758	Bushels 22.3
1909.....	6,461,680	26.2	2,555,045	19.7	2,359,395	26.3	68,420	17.9	128,358	22.0
1910.....	6,595,088	27.1	2,732,166	16.5	2,543,858	28.1	71,339	11.5	115,952	20.1
1911.....	6,218,035	21.6	3,465,765	13.4	2,312,610	13.9	85,687	10.9	85,015	10.8
1912.....	6,076,057	27.1	3,202,491	15.3	2,037,943	23.1	115,126	16.0	56,703	20.3
1913.....	6,817,127	14.6	3,022,610	20.0	2,019,096	25.9	159,317	19.6	97,694	21.2
1914.....	6,530,078	25.3	3,703,524	18.3	2,041,999	34.8	174,459	16.0	97,792	22.8
1915.....	6,990,031	32.6	3,640,965	19.6	2,125,179	34.7	211,790	16.4	93,408	32.1
1916.....	6,740,803	28.2	3,310,313	20.8	2,174,736	38.5	148,702	21.5	99,650	33.6
Average....	6,529,769	25.7	3,130,943	17.9	2,218,739	27.6	124,884	16.0	96,704	22.8
27-year av..	6,068,391	24.9	2,266,302	16.9	1,890,438	27.0	129,755	16.6	99,688	22.0
27-year av..	.....	Pounds 1,394	.....	Pounds 1,014	.....	Pounds 864	.....	Pounds 930	.....	Pounds 1,056

¹ Compiled from the 1916 annual report of the Nebraska State Board of Agriculture.

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TABLE 2—Production and acre incomes for corn, wheat, and oats in the State of Nebraska, 1890 to 1916¹

Crop	Average price per bushel	Yield per acre	Acre income
	<i>Cents</i>	<i>Bushels</i>	<i>Dollars</i>
NINE-YEAR PERIOD, 1890 TO 1898			
Corn.....	28.0	20.5	5.74
Winter wheat.....	54.0	14.7	7.94
Oats.....	16.3	24.9	4.06
NINE-YEAR PERIOD, 1899 TO 1907			
Corn.....	39.3	28.6	11.24
Winter wheat.....	64.0	18.1	11.58
Oats.....	28.3	28.5	8.07
NINE-YEAR PERIOD, 1908 TO 1916			
Corn.....	57.2	25.7	14.70
Winter wheat.....	90.0	17.9	16.11
Oats.....	35.0	27.6	9.66
27-YEAR PERIOD, 1890 TO 1916			
Corn.....	42.0	24.9	10.46
Winter wheat.....	69.0	16.9	11.66
Oats.....	27.0	27.0	7.29

¹Compiled from the 1916 annual report of the Nebraska State Board of Agriculture.

TABLE 3—Relative yields and acre incomes for corn, wheat, and oats at the Nebraska Experiment Station and in Lancaster County,¹ in which county the Station is located. Average, 1902 to 1916

Crop	Price per bushel	Yield per acre		Acre income	
		Lancaster County	Experiment Station	Lancaster County	Experiment Station
	<i>Cents</i>	<i>Bushels</i>	<i>Bushels</i>	<i>Dollars</i>	<i>Dollars</i>
Corn.....	51	26.5	57.2	13.52	29.17
Winter wheat....	81	21.3	36.2	17.25	29.32
Oats.....	32	23.0	56.0	7.36	17.92

¹The County yields have been compiled from the annual reports of the Nebraska Bureau of Crop Statistics and of the Nebraska State Board of Agriculture.

Thruout the greater part of the State oats are grown with far less profit and more frequent actual loss than either corn or winter wheat. The reason for growing oats is primarily to supply the individual farmer's requirements for a favorite horse feed. In

eastern Nebraska, oats are grown to facilitate a change in the rotation from corn to winter wheat. The organization of labor on many farms also requires that a portion of the land be sown to some small grain crop in the spring. Of all the spring-sown small grain crops, oats appear to be most practical for the average farm, except in southwestern Nebraska, where barley is held in higher favor. The superior feeding value of the straw is a special inducement to grow oats rather than other spring-sown grains.

As an average for 27 years for the entire State, the approximate yields of corn, wheat, oats, rye, and barley have been 24.9, 16.9, 27.0, 16.6, and 22.0 bushels per acre. The actual production of crops differing in weight per bushel can be compared more directly in pounds than in bushels per acre. Grains enclosed in a hull which has very little food value, such as oats and barley, may also be compared with hull-less grain to best advantage by their relative yields free from hull. Allowing 30 per cent for hull in oats and 15 per cent hull for barley, the net yields of grain for the above five crops have been, respectively, 1394, 1014, 605, 930, and 898 pounds per acre.

The distribution of the spring-sown small grain crops in Nebraska is shown in figures 1, 2, and 3.

Because of the large acreage and because of the relatively low yield and small profit from oats, this crop seems to offer a good field for investigation.

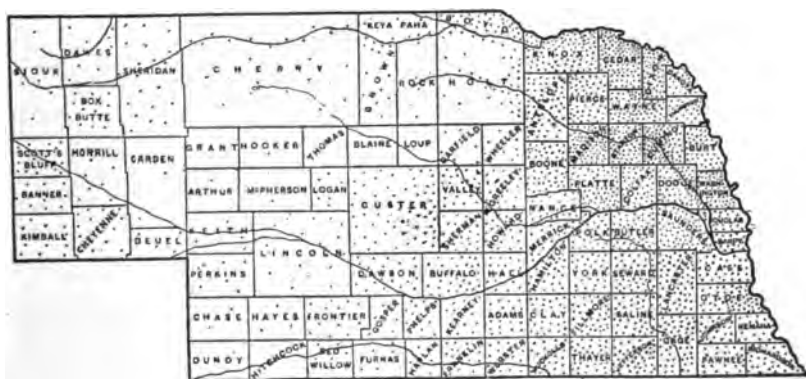


Fig. 1—Distribution of oats in 1916, one dot for each 1,000 acres grown. Compiled from the 1916 annual report of the Nebraska State Board of Agriculture

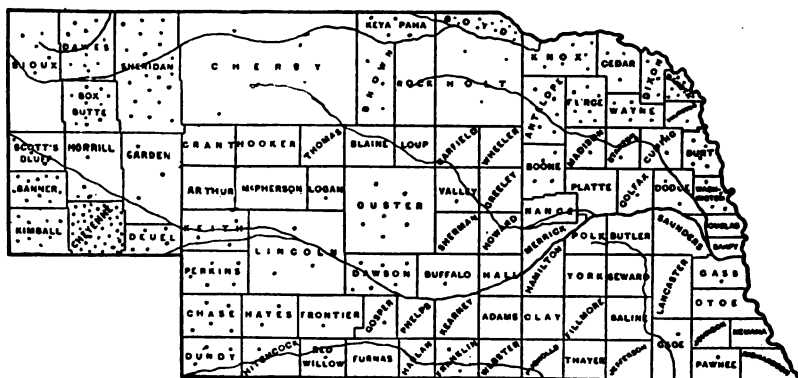


Fig. 2—Distribution of spring wheat in 1916, one dot for each 1,000 acres grown. Compiled from the 1916 annual report of the Nebraska State Board of Agriculture

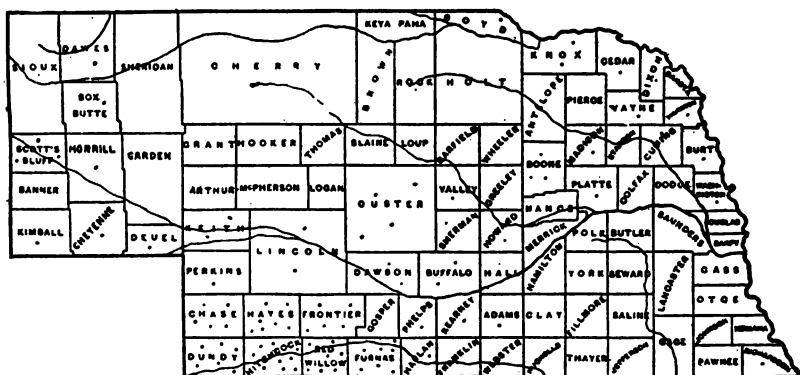


Fig. 3—Distribution of barley in 1916, one dot for each 1,000 acres grown. Compiled from the 1916 annual report of the Nebraska State Board of Agriculture

ADAPTATION AND VARIETIES

In order that a crop shall produce successfully, it is essential that the environmental conditions fit the needs of the crop. For example, cotton and rice are not grown in this State because environmental conditions are unsuited. On the other hand, corn and winter wheat are especially well adapted to a large part of the State. In general, oats stand between these two classes of

crops in adaptation to Nebraska climatic conditions. While being grown extensively in this State, production is confined to a very limited number of varieties, and even these seldom reach their maximum development, because of the unfavorable environment. This crop is best suited to a cool growing season such as exists in the northern states, Canada, England, and Scotland, and it suffers severely when exposed to intense heat during the fruiting period. In the greater part of Nebraska, the oats crop must usually endure a period of dry, hot weather just before harvest. Therefore, because of a consistently cooler climate, the northern half of the State is more favorable to oats culture than is the southern half, and profitable commercial oats growing is quite largely confined to this section, with the most extensive production in the northeastern part.



Fig. 4—General view of oats variety test plats (1916)

Recognizing the general lack of adaptation of oats to Nebraska conditions, the Experiment Station early undertook to determine the type of oats best suited here. Variety tests indicated that extreme earliness would permit the crop to ripen with less danger from heat and drouth and less likelihood of rust and lodging. In the search for early oats suited to Nebraska conditions, the now well-known Kherson variety was introduced from Kherson,

Russia, and first tested by T. L. Lyon, of the Nebraska Station, in 1898. Further tests by the Experiment Station and extensive coöperative trials indicated that this variety was superior to any other which had been grown in the State. It quickly came into general use and has been adopted as the standard variety in Nebraska, except in the more favored oats districts where later varieties are still grown extensively.

More extended variety tests, reported upon by E. G. Montgomery in 1910 and continued to the present time, indicate conclusively that the principle of earliness in oats is very important. The early varieties develop rapidly and reach the fruiting stage 6 to 12 days earlier than do the late ones. This stage, for the early varieties, is reached about the middle of June in eastern Nebraska, and at this time the weather is usually favorable for crop growth. About the Fourth of July, however, as the early oats are ripening, the weather normally becomes hotter and the ground drier. The late varieties at this time are just in their prime and under these conditions are unable to fill well, because of premature ripening. Thus, it usually happens that the early varieties are able to grow and mature under the more favorable conditions. It is the ability to escape the heat and drouth of summer that results in larger yields.

Tables 4 and 5 contain the results for two groups of representative early and late varieties which have been tested for yield during 12 consecutive years, 1905—1916. Station seed from the preceding crop has been planted each year. These tests, as well as other variety tests which follow, have been made mostly in duplicate or triplicate in plats varying from 1/15 to 1/30 acre in size. Altho systematically distributed check plats of Kherson oats have been grown, they have seldom been used to correct the yields of intervening plats.

The small and large seeded varieties have been drilled respectively at the rates of 10 and 12 pecks per acre with a press drill. This was done in order to sow a somewhat similar number of seeds per acre.

During this 12-year period, 1905 to 1916, the early varieties averaged 11.1 bushels greater yield per acre than did the later group. There was an average difference of 8 days in time of ripening between the two groups, and 5 inches difference in height of crop. The three early varieties are each clearly superior to any of the later oats. The Burt, Texas Red, and Kherson yielded respectively 61.3, 57.7, and 53.9 bushels per acre. It is evident that the Kherson has been surpassed by both Burt and Texas Red in this test.

TABLE 4—Oats variety test, 1905 to 1916

Variety	Yield per acre													
	1905	1906	1907	1908	1909	1910	1911	1912	1913	1914	1915	1916	Av.	
EARLY VARIETIES														
Kherson	Bu. 82.7	Bu. 36.4	Bu. 49.0	Bu. 54.0	Bu. 67.2	Bu. 41.7	Bu. 38.5	Bu. 37.4	Bu. 44.8	Bu. 69.7	Bu. 40.1	Bu. 85.4	Bu. 53.9	
Texas Red	81.7	44.1	42.5	65.0	77.6	53.1	42.5	35.6	60.3	71.3	56.0	87.1	59.7	
Burt	85.5	42.3	48.5	64.3	74.1	60.7	38.2	38.6	61.4	76.7	65.9	79.2	61.3	
LATE VARIETIES														
Swedish Select (1901)	69.2	42.8	32.5	44.0	67.1	55.8	41.2	26.4	45.9	60.7	35.2	83.6	50.4	
American Banner	76.3	40.2	31.0	34.3	61.7	51.9	35.7	28.0	33.9	47.1	34.5	67.5	45.2	
University No. 6	77.1	34.6	29.4	49.0	68.0	45.2	32.6	25.9	22.0	49.1	31.0	66.3	44.2	
Lincoln	85.2	42.3	28.5	43.6	71.6	51.8	39.1	29.5	40.3	53.5	30.7	70.3	48.9	
Average of 3 early varieties	83.3	40.9	46.7	61.1	73.0	51.8	39.7	37.2	55.5	72.6	54.0	83.9	58.3	
Average of 4 late varieties	77.0	40.0	30.4	42.7	67.1	51.2	37.2	27.5	35.5	52.6	32.9	71.9	47.2	
Difference	6.3	0.9	16.3	18.4	5.9	0.6	2.5	9.7	20.0	20.0	21.1	12.0	11.1	

TABLE 5—*Summary of variety characters, 1905 to 1916*

Variety	Date of planting	Date of heading	Date of ripening	Length of growing period	Length of fruiting period	Height of plants	Lodging	Hull	No. of seeds per pound	Color of grain	Yield per acre
				Days	Days	Inches	Per cent	Per cent			Bu.
EARLY VARIETIES											
Kherson	April 4	June 15	July 8	95	23	35	15	29.0	28,819	Yellow	53.9
Texas Red	April 4	June 16	July 11	98	25	35	13	29.1	22,763	Reddish	59.7
Burt	April 4	June 12	July 6	93	24	35	13	27.9	23,144	" yellow	61.3
LATE VARIETIES											
Swedish Select (1901)	April 4	June 21	July 15	102	24	39	17	29.8	25,051	White	50.4
American Banner . . .	April 4	June 23	July 17	104	24	40	17	32.7	23,489	White	45.2
University No. 6 . . .	April 4	June 22	July 16	103	24	40	20	29.5	18,713	White	44.2
Lincoln	April 4	June 23	July 16	103	23	40	16	33.5	23,716	White	48.9
Av. of 3 early varieties	April 4	June 14	July 8	95	24	35	14	28.7	24,909	.....	58.3
Av. of 4 late varieties	April 4	June 22	July 16	103	24	40	18	31.4	22,742	.....	47.2
Difference . . . . .	.....	.....	.....	8	0	5	4	2.7	2,167	.....	11.1

Tables 6 and 7 contain the results obtained from all varieties tested in field plats thruout the last 6 years. These may again be divided into early and late groups, differing 6 days in length of growing period and 4 inches in height of plants. The early varieties averaged 16.7 bushels greater yield than the late group. In this 6-year period, the Burt, Texas Red, and June varieties surpassed the Kherson 7.3, 6.1, and 1.2 bushels per acre, respectively. Under favorable climatic conditions, the difference in time of ripening between the two groups would be greater. The Nebraska climate promotes premature ripening of late varieties.

The yields are given in table 8 for all varieties of oats which have been tested in the field plats for a period of at least 4 consecutive years during the period, 1902 to 1916. Many other varieties have been grown for a shorter period, but the results are not included in the table, because of the brief duration of the tests.



Fig. 5—Early versus late varieties of oats. From left to right: Lincoln, Kherson, Swedish Select

Since the varieties were not all grown during identically the same years, the customary mean yields for all varieties tested would not be comparable. To overcome this, Kherson was selected as a standard, and the other varieties were compared with it for the years in which they were grown, the relation being

TABLE 6—*Oats variety test, 1911 to 1916*

Variety	Yield per acre						Average yield
	1911	1912	1913	1914	1915	1916	
EARLY VARIETIES							
Kherson.....	<i>Bushels</i> 38.5	<i>Bushels</i> 37.4	<i>Bushels</i> 44.8	<i>Bushels</i> 69.7	<i>Bushels</i> 40.1	<i>Bushels</i> 85.4	<i>Bushels</i> 52.7
Texas Red.....	42.5	35.6	60.4	71.3	56.0	87.1	58.8
Burt.....	38.2	38.6	61.4	76.7	65.9	79.2	60.0
June.....	32.0	33.9	53.3	63.9	54.9	85.5	53.9
LATE VARIETIES							
Swedish Select (1901) ¹	41.2	26.4	45.9	60.7	35.2	83.6	48.8
American Banner.....	35.7	28.0	33.9	47.1	34.5	67.5	41.1
University No. 6.....	32.6	25.9	22.0	49.1	31.0	66.3	37.8
Lincoln.....	39.1	29.5	40.3	53.5	30.7	70.3	43.9
Swedish Select (Regenerated).....	35.7	20.2	19.5	51.0	31.0	72.1	38.3
Garton No. 855.....	23.7	14.8	13.8	51.8	37.1	73.1	35.7
Garton No. 70.....	32.3	30.3	16.7	25.9	23.9	71.9	33.5
Garton No. 611.....	31.9	28.4	24.8	43.3	35.2	71.0	39.1
Garton No. 1174.....	28.7	25.0	33.6	58.1	39.4	76.9	43.6
Green Russian.....	21.6	28.1	25.5	31.2	25.8	78.5	35.1
Average of 4 early varieties.....							
Average of 10 late varieties.....							
Difference.....							
	37.8	36.4	55.0	70.4	54.2	84.3	56.4
	32.3	25.6	27.6	47.2	32.4	73.1	39.7
	5.5	10.8	27.4	23.2	21.8	11.2	16.7

¹Swedish Select (1901) oats is the original Swedish Select obtained from the U. S. Dept. of Agr. in 1901.

TABLE 7—Summary of variety characters, 1911 to 1916

Variety	Date of planting	Date of heading	Date of ripening	Length of growing period	Length of fruiting period	Height of plants	Lodging	Hull	No. of seeds per pound	Color of grain	Yield per acre
EARLY VARIETIES											
Kherson	April 10	June 15	July 8	Days 89	Days 23	Inches 35	Per cent 17	Per cent 29.0	28,819	Yellow	Bu. 52.7
Texas Red	April 10	June 15	July 8	89	23	35	12	29.1	22,763	Reddish	58.8
Burt	April 10	June 12	July 6	87	24	34	8	27.9	23,144	Yellowish	60.0
June	April 10	June 12	July 6	87	24	35	18	27.8	27,639	Yellow	53.9
LATE VARIETIES											
Swedish Select (1901)	April 10	June 20	July 11	92	21	38	16	29.8	25,051	White	48.8
American Banner	April 10	June 21	July 14	95	23	39	18	32.7	23,489	White	41.1
University No. 6	April 10	June 22	July 13	94	21	39	18	29.5	18,713	White	37.8
Lincoln	April 10	June 22	July 13	94	21	39	18	33.5	23,716	White	43.9
Swedish Sel. (Regen.)	April 10	June 22	July 13	94	21	40	18	31.0	19,022	White	38.3
Garton 855	April 10	June 24	July 14	95	20	40	18	35.1	19,821	White	36.7
Garton 70	April 10	June 22	July 14	95	22	40	18	38.2	20,457	Black	33.5
Garton 611	April 10	June 21	July 13	94	22	40	18	31.5	20,711	White	39.1
Garton 1174	April 10	June 21	July 13	94	22	39	18	29.9	26,005	Yellow	43.6
Green Russian	April 10	June 21	July 14	95	23	40	18	37.3	22,899	White	35.1
Av. of 4 early varieties	April 10	June 14	July 7	88	23	35	14	28.5	25,591	.....	56.4
Av. of 10 late varieties	April 10	June 22	July 13	94	21	39	18	32.9	21,986	.....	39.7
Difference	.....	.....	.....	6	2	4	4	4.4	3,605	.....	16.7

expressed in per cent of the Kherson yield. The relative standing, therefore, of each variety as compared with Kherson is given in the next to the last column, and the corresponding relative yield in bushels per acre is shown in the last column. Burt, Texas Red, and June again are superior to Kherson oats. The Burt yield is 15 per cent superior to the Kherson, 29 per cent superior to the best late variety, and 93 per cent better than the poorest late variety. The average superiority of the six early varieties is 13 bushels over the late group.



Fig. 6—Kherson oats



Fig. 7—Swedish Select oats

In 1910, 789 lots of seed were obtained for classification studies from the various experiment stations and seed houses, which included practically all the oats varieties grown in this country. These have been grown for 6 years in nursery plats and have afforded an opportunity for careful examination and observation regarding characteristics of growth and seed production

under Nebraska conditions. None of these varieties have given promise of being superior to the best already grown in the variety yield tests.

A number of representative types of oats are shown in figures 6 to 10. Figure 6 is a typical head of Kherson oats. This type of head is also characteristic of all early varieties grown in this State. It is commonly known as the "true" or "spreading" panicle. Kherson has for many years been the standard variety of oats for a large part of Nebraska.



Fig. 8—Canadian oats



Fig. 9—White Russian oats

A typical head of Swedish Select oats is shown in figure 7. This is a medium-late variety and is grown rather extensively in parts of the State. In growth habit, it is representative of the small group of late varieties indicated in tables 4 to 9. This is the same type of panicle as that in figure 6, but is larger and more spreading.



Fig. 10—Hull-less oats.



Fig. 11—Various types of oats spikelets

Figure 8 shows a typical head of Canadian oats. This variety has very large, coarse straw and is very late in maturing. It represents a type that is not at all suited to Nebraska conditions. While the large, plump seed of this or similar varieties imported from the northern states and Canada are very attractive, no attempts should be made to grow them here.

White Russian oats, shown in figure 9, is of the "side panicle" type which is characteristic of a few late varieties grown chiefly in the cooler and more humid sections of the country. Such oats are frequently classified as side oats, in contrast with the true panicle oats. No early varieties of this type have thus far been found to be adapted to Nebraska conditions.

Figure 10 is a head of hull-less or "naked" oats. This type of oats differs from the common varieties chiefly in two respects: (1) The hull, or flowering glume, does not adhere to the grain; (2) the spikelet contains from 3 to 10 grains, instead of 1 to 3. Varieties of this type are not suited to Nebraska conditions.

Different types of oats spikelets are shown in figure 11 as follows: (1) Spikelet 2-grained, 2-awned, with long hairs at base of grain and on the hull; (2) spikelet 2-grained, 2-awned, with basal hairs; (3) spikelet 3-grained, 3-awned, with basal hairs; (4) spikelet 2-grained, 1-awned, with no basal hairs; (5) spikelet 1-grained, 1-awned, with no basal hairs; (6) spikelet 2-grained, awnless, with no basal hairs; (7) spikelet 1-grained, awnless, with no basal hairs; (8) spikelet 3 (or more) grained, awnless, with no basal hairs.

Figure 12 shows two typical plants grown from seed bearing the same name. The seed for No. 1 came from Delaware, that for No. 2 came from Utah. This is plainly a case of confusion of variety names. Such cases are rather frequent, and they suggest that care is necessary in purchasing seed oats in order to make sure that the desired variety is being obtained. Two very distinct types of growth habit are also illustrated by these two plants.

IMPROVEMENT OF OATS BY BREEDING

Varieties, as commonly grown, have a rather uniform appearance, altho close analysis may show the presence of a number of more or less distinct types of oats. These types may be quite distinct and may or may not have practical importance. Again, they may be similar in appearance and the difference ascertained only thru careful yield tests after having been isolated from the general variety.

Since oats are, at best, a poorly adapted crop for Nebraska conditions, an attempt to select and multiply strains somewhat

better adapted than the bulk of the original variety is attended with considerable promise. Such an attempt has been made by the Nebraska Experiment Station and has apparently met with a certain measure of success.



Fig. 12—Two distinct varieties of oats bearing the same name

Since Kherson oats was the most commonly grown variety in the State and possessed many desirable characters, this variety was chosen as a foundation for improvement. Seven hundred and fifty individual oat heads were selected at random in 1907 from a field of Kherson oats originating from an 1896 importation from Russia. In selecting these heads, the chief considerations

were that they should conform to the general Kherson type of head and contain not less than 50 seeds.

In 1908, fifty seeds from each head were planted in individual 2-foot rows spaced 10 inches apart. This approximated the usual rate of planting under field conditions.



Fig. 13—Method of testing individual head selections of Kherson oats the first year. Seven hundred fifty initial selections were made

Based upon the 1908 results, 300 strains were discarded because they appeared to have slightly weaker straw. Of the remaining strains, the 265 giving the highest yields were tested in 1909. They were planted at the normal rate in duplicate 12.5-foot nursery rows, with a check plat of the original seed after every tenth row.

Following this test, all except the 75 most promising strains were eliminated. These were planted in 1910 in 12.5-foot nursery rows—the entire series being repeated ten times.

In 1911 the number of strains was further reduced to forty all of which have been grown at the normal rate of planting during the 6 years, 1911 to 1916, in 16-foot nursery plats containing 5 rows spaced 10 inches apart (figure 14.) The plats have been systematically repeated six to eight times each year with checks of the original seed planted after every fifth strain. Beginning with 1915, the two outer rows of each plat have been discarded, and the yield determined for the three center rows only.



Fig. 14—Oats nursery containing 40 strains of Kherson oats repeated 8 times in 5-row nursery blocks. The outer rows of each block are discarded at harvest. Strain No. 35 in center

The strain numbers by which these 40 strains are known originate in the 1910 ranking for yield. They were numbered from 1 to 40 according to their rank. The results for the last 6 years follow in tables 9 and 10.

In the 6-year nursery test, 25 strains have yielded better than the original seed, while 15 strains have yielded less. The best two strains have yielded nearly 5 bushels better. While the grain of the original Kherson oats is chiefly yellow, it is interesting to note that the two highest ranking strains, Nos. 5 and 21, are light

yellow and white respectively. Since strain No. 21 is white and has yielded only 0.18 bushel less per acre than No. 5, and appears equally meritorious in other regards, this strain may be considered as the most worthy of increase and dissemination.

TABLE 9—Yield test of forty Kherson oats strains grown in nursery, 1911 to 1916

Strain No.	Yield per acre						
	1911	1912	1913	1914	1915	1916	Average
	<i>Bushels</i>	<i>Bushels</i>	<i>Bushels</i>	<i>Bushels</i>	<i>Bushels</i>	<i>Bushels</i>	<i>Bushels</i>
Original	40.07	27.84	68.40	56.21	51.12	72.10	52.62
5	44.79	28.47	75.60	58.62	56.96	81.01	57.57
21	44.02	28.15	67.64	66.51	63.10	74.95	57.39
33	39.66	31.12	71.14	60.98	55.24	79.60	56.29
11	44.79	25.50	67.37	59.32	57.26	81.70	55.99
22	41.91	25.32	71.95	58.78	52.69	85.14	55.96
30	41.42	25.77	68.04	62.87	55.61	81.48	55.86
16	38.04	28.92	65.07	56.08	66.55	80.12	55.79
27	46.73	28.78	68.40	61.48	53.14	73.68	55.37
17	40.92	30.62	66.70	62.34	52.76	78.55	55.31
1	40.29	27.21	66.51	62.63	56.14	77.20	54.99
18	39.98	27.52	66.51	59.68	59.88	76.14	54.95
4	38.04	28.69	70.56	60.90	59.14	72.33	54.94
6	46.00	28.56	68.22	60.22	55.77	68.50	54.54
3	42.32	27.48	71.81	61.09	54.34	69.85	54.48
9	40.74	24.51	62.38	63.32	60.94	74.65	54.42
10	38.58	26.04	60.22	63.28	52.76	85.15	54.34
23	45.10	28.02	68.63	59.90	49.10	74.05	54.13
7	42.18	26.40	64.26	61.44	54.79	74.80	53.98
38	40.34	29.73	65.92	57.10	54.41	75.47	53.83
39	37.91	29.28	63.95	58.42	56.96	76.23	53.79
29	38.85	25.18	67.68	60.72	56.06	74.13	53.77
12	39.62	28.51	71.24	59.54	49.02	74.13	53.68
13	41.33	28.06	65.07	56.88	55.54	74.36	53.54
25	43.48	29.14	69.80	60.94	48.64	68.50	53.42
15	40.29	28.74	61.57	61.07	54.34	72.78	53.13
14	37.95	28.92	65.84	58.10	51.34	73.38	52.59
32	38.13	28.15	60.94	59.50	50.14	78.25	52.52
2	44.07	27.84	68.31	57.63	46.39	70.38	52.44
8	40.56	24.91	61.48	58.02	52.76	75.62	52.22
19	38.18	24.42	63.90	59.14	60.64	66.78	52.18
40	37.10	26.04	62.47	51.73	52.54	81.02	51.82
20	40.16	25.86	61.88	61.48	50.74	70.68	51.80
26	37.42	29.00	65.30	57.38	50.37	69.25	51.45
24	42.54	28.38	64.08	57.96	46.92	63.86	50.62
37	36.83	29.55	63.59	53.88	46.17	70.83	50.14
31	37.69	24.96	63.72	58.46	44.15	71.73	50.12
28	42.94	25.27	60.98	58.10	38.82	72.78	49.81
36	36.02	26.89	59.40	52.44	48.12	66.93	48.30
34	38.63	30.40	51.17	38.49	26.23	59.21	40.69
35	23.65	20.51	41.24	48.71	32.08	60.78	37.83

TABLE 10—*Description of forty Kherson oats strains grown in nursery. Average, 1911 to 1916*

Strain No.	Color of grain	Date of planting	Date of heading	Date of ripening	Length of growing period	Length of fruiting period	Height of plants	Amount of lodging
					Days	Days	Inches	Per cent
Original..	Yellow.....	April 6	June 14	July 8	98	24	33.1	17
5.....	Medium yellow..	April 6	June 13	July 7	92	24	33.9	17
21.....	White.....	April 6	June 15	July 8	98	23	33.1	17
33.....	White.....	April 6	June 13	July 8	98	25	33.5	17
11.....	White.....	April 6	June 14	July 8	93	24	31.9	18
22.....	Medium yellow..	April 6	June 14	July 8	93	24	32.7	17
30.....	Yellow.....	April 6	June 16	July 8	98	22	33.5	17
16.....	Yellow.....	April 6	June 14	July 8	93	24	33.5	17
27.....	Medium white...	April 6	June 16	July 8	93	22	34.3	17
17.....	Medium yellow..	April 6	June 14	July 8	93	24	33.1	17
1.....	Medium white...	April 6	June 16	July 9	94	23	33.9	17
18.....	Medium yellow..	April 6	June 15	July 8	93	23	33.5	17
4.....	Yellow.....	April 6	June 16	July 9	94	23	33.9	17
6.....	Medium yellow..	April 6	June 14	July 7	92	23	31.9	20
3.....	Yellow.....	April 6	June 15	July 8	93	23	32.7	17
9.....	Medium white...	April 6	June 16	July 8	93	22	33.9	17
10.....	Yellow.....	April 6	June 16	July 8	93	22	32.7	17
23.....	Yellow.....	April 6	June 14	July 7	92	23	31.9	17
7.....	Medium white...	April 6	June 15	July 8	93	23	33.9	20
38.....	Yellow.....	April 6	June 16	July 8	93	22	32.7	17
39.....	Yellow.....	April 6	June 16	July 8	93	22	33.1	17
29.....	Medium yellow..	April 6	June 14	July 8	93	24	32.3	17
12.....	Yellow.....	April 6	June 15	July 8	93	23	33.1	18
13.....	Medium yellow..	April 6	June 15	July 8	93	23	32.7	18
25.....	Yellow.....	April 6	June 15	July 7	92	22	31.9	17
15.....	Yellow.....	April 6	June 16	July 8	93	22	33.1	19
14.....	Medium yellow..	April 6	June 16	July 8	93	22	32.3	18
32.....	Medium white...	April 6	June 14	July 8	93	24	31.5	17
2.....	Medium yellow..	April 6	June 14	July 8	93	24	32.3	17
8.....	Yellow.....	April 6	June 14	July 7	92	23	32.3	17
19.....	Reddish white...	April 6	June 16	July 8	93	22	32.3	17
40.....	Medium yellow..	April 6	June 14	July 7	92	23	32.3	19
20.....	Yellow.....	April 6	June 17	July 9	94	22	34.9	17
26.....	White.....	April 6	June 13	July 8	93	25	31.9	18
24.....	Medium yellow..	April 6	June 14	July 8	93	24	31.9	19
37.....	Yellow.....	April 6	June 15	July 8	93	23	32.7	17
31.....	Yellow.....	April 6	June 13	July 8	93	25	33.1	17
28.....	Medium yellow..	April 6	June 16	July 8	93	22	32.7	17
36.....	Yellow.....	April 6	June 17	July 9	94	22	33.5	17
34.....	White.....	April 6	June 19	July 10	95	21	33.1	17
35.....	White.....	April 6	June 20	July 11	96	21	37.4	17

Six of the 40 strains were distinctly white oats, but there was no apparent difference in the grain in other respects. The two distinctly later ripening strains were far inferior in yield, which correlation has also been found to exist for oats varieties.

Twelve of the Kherson oats strains have been tested 3 to 4 years in field plats in a manner similar to the variety tests described earlier. (Figure 15.) The results are given in tables 11 and 12. Strain No. 21, white Kherson oats, ranked first in yield, whereas it was second in the nursery. Its yield was 7.8 bushels per acre greater than the original Kherson as an average for the 4-year period. Strain No. 5 has been grown only 3 years in field plats, during which time it has yielded 3.3

bushels per acre more than the original Kherson and 2.6 bushels less than strain No. 21. During the last two years, however, strain No. 5 has taken the lead and is apparently equal in yielding power to No. 21, as is indicated by the nursery record.



Fig. 15—Method of testing Kherson oats strains in field plats. (1916.) The plats are the width of a grain drill and are harvested with one swath of the binder. From left to right: Strains Nos. 19, 35, 5

TABLE 11—Yield test of Kherson oats strains grown in field plats, 1913 to 1916

Strain Number	Yield per acre				
	1913	1914	1915	1916	Average
	<i>Bushels</i>	<i>Bushels</i>	<i>Bushels</i>	<i>Bushels</i>	<i>Bushels</i>
Original.....	44.4	58.9	29.9	83.0	54.1
21.....	58.0	71.7	32.4	85.4	61.9
23.....	61.0	67.3	27.7	85.9	60.5
15.....	51.8	50.4	26.5	77.3	51.5
25.....	62.1	64.2	30.7	83.9	60.2
6.....	64.1	63.2	24.4	81.6	58.3
33.....	58.5	63.7	35.7	86.1	61.0
27.....	50.8	67.1	31.7	81.9	57.9
38.....	62.1	64.9	31.9	81.1	60.0
35.....	33.9	53.0	22.8	76.7	46.6
4.....	61.0	67.8	30.5	80.3	59.9
5.....	.....	65.2	33.3	83.3	.....
19.....	.....	50.1	21.4	74.8	.....

TABLE 12—*Description of Kherson oats strains grown in field plats.
Average, 1913 to 1916*

Strain No.	Color of grain	Date of planting	Date of heading	Date of ripening	Length of growing period	Length of fruiting period	Height of plants	Amount of lodging
					<i>Days</i>	<i>Days</i>	<i>Inches</i>	<i>Per cent</i>
Original..	Yellow.....	April 9	June 16	July 10	92	24	39.4	21
21.....	White.....	April 9	June 17	July 10	92	23	40.2	24
23.....	Yellow.....	April 9	June 16	July 9	91	23	39.4	27
15.....	Yellow.....	April 9	June 18	July 10	92	22	40.9	38
25.....	Yellow.....	April 9	June 16	July 9	91	23	39.0	23
6.....	Medium yellow..	April 9	June 16	July 9	91	23	38.6	25
33.....	White.....	April 9	June 16	July 10	92	24	39.0	25
27.....	Medium white...	April 9	June 17	July 10	92	23	40.6	25
38.....	Yellow.....	April 9	June 17	July 10	92	23	39.4	25
35.....	White.....	April 9	June 22	July 14	96	22	42.9	25
4.....	Yellow.....	April 9	June 17	July 10	92	23	39.8	26



Fig. 16—Ten-acre field of Nebraska No. 21 white Kherson oats, which yielded at the rate of 78.5 bushels an acre in 1916. As an average for 4 years, it has surpassed the original Kherson, from which it was selected, 7.8 bushels an acre

The consistent superiority in yield of strain No. 21 in the field plats as well as in the nursery indicates a marked improvement over the original Kherson from which it was selected.

The white color would also give it an added value on the general market.

Figure 16 shows a 10-acre increase field of this strain No. 21 grown in 1916. It yielded at the rate of 78.2 bushels per acre. The seed was distributed to farmers during the early spring of 1917, under the name of Nebraska No. 21 oats.

Table 13 gives the relative yields of Burt, Texas Red, Kherson strain No. 21, and the original Kherson oats.

TABLE 13—*Relative yields of the three highest yielding varieties and strain No. 21. Average, 1913 to 1916*

Variety	Color	Yield per acre
		<i>Bushels</i>
Kherson Oats No. 21.....	White.....	61.9
Original Kherson.....	Yellow.....	54.1
Burt.....	Reddish yellow.....	64.5
Texas Red.....	Red.....	62.3

The data in table 13 indicate a very important improvement over the original Kherson oats. However, two varieties—Burt and Texas Red—have been found to exceed the yield of strain No. 21 by 2.6 bushels and 0.4 bushel respectively. This suggests that variety tests may be at least as important as crop breeding.

An attempt to select a superior strain from Burt oats will be started in 1917. Unless a superior strain of Burt is found, both Burt and Kherson strain No. 21 may be regarded as practically equal. The superiority of Burt over common Kherson is, however, somewhat more definitely established than is that of Kherson strain No. 21, because of the much greater duration of the comparative yield tests.

IRRIGATED VERSUS UNIRRIGATED OATS FOR SEED

In occasional years, such as 1911, farmers on unirrigated land have had difficulty in securing seed (grown without irrigation), which they believed satisfactory. An investigation was started in 1912 to determine whether it would be safe for the eastern Nebraska farmers to secure seed oats grown under irrigation in western Nebraska.

Seed of both Kherson and Swedish Select oats grown for many years under irrigation in Scotts Bluff County, Nebraska, was secured during each of the last 5 years and compared at the Experiment Station at Lincoln with locally-grown seed of the

same varieties. Each season the plots were repeated two to three times. The results are given in table 14.

During the 5-year period, the seed of both varieties grown under irrigation has rather consistently outyielded the seed of home-grown unirrigated oats. The average difference has been

TABLE 14—*Yields from irrigated and unirrigated seed oats, 1912 to 1916*

Variety and previous treatment	Yield per acre					
	1912	1913	1914	1915	1916	Average
	<i>Bushels</i>	<i>Bushels</i>	<i>Bushels</i>	<i>Bushels</i>	<i>Bushels</i>	<i>Bushels</i>
Kherson, unirrigated.....	41.9	43.1	57.5	29.5	65.9	47.6
Kherson, irrigated.....	45.1	57.6	58.4	30.7	63.1	51.0
Swedish Select, unirrigated	23.6	32.9	46.7	27.0	37.6	33.6
Swedish Select, irrigated..	25.6	38.7	49.4	31.0	39.3	36.8

3.4 bushels per acre for Kherson and 3.2 bushels for the Swedish Select oats. The investigation suggests that irrigated seed oats grown in western Nebraska may be substituted for unirrigated seed of the same variety in eastern Nebraska. These varieties have not changed their growth habits as the result of being grown under irrigation for many years.

EFFECT OF GRADING ON SEED VALUE OF OATS

An experiment was started in 1905 to determine the effect of continuous grading upon the seed value of Kherson oats. A similar test with American Banner, a later-maturing variety, was started in 1909. The tests have been made each year in duplicate, on plats 1-30 to 1-15 acre in size, and all seeding was done with a press drill. For all Kherson grades, the rate of seeding was 10 pecks per acre. For the American Banner, the rate was 12 pecks.

In the first year of the tests, the oats were divided into grades by means of directing the seed into an upward moving air blast. The lighter seed was carried over, while the heavier seed fell down and out at the bottom of the machine. By this means the heaviest one-fourth and the lightest one-fourth of the seed were secured in separate lots for comparison with the original seed. Each year since, the lightest one-fourth seed has been secured from the crop previously grown from the lightest one-fourth seed. Similarly, the heaviest one-fourth seed has been secured from the

TABLE 15—Yields of light and heavy seed of Kherson oats as separated by a fanning mill, 1905 to 1916

Kind of seed planted	Yield per acre													Av. for 12 years
	1905	1906	1907	1908 ¹	1909	1910	1911	1912	1913	1914	1915	1916		
	Bu. (2)	Bu. (3)	Bu. (4)	Bu. (5)	Bu. (6)	Bu. (7)	Bu. (8)	Bu. (9)	Bu. (10)	Bu. (11)	Bu. (12)	Bu. (13)	Bushels (14)	
Original unselected.....	88.4	58.1	49.8	49.1	66.2	38.2	40.6	50.9	42.6	56.4	30.0	85.8	54.68	
Heaviest one-fourth.....	91.0	58.4	49.0	52.0	64.0	38.6	37.0	51.6	48.0	58.7	31.4	85.7	55.45	
Lightest one-fourth.....	90.1	59.5	43.8	49.1	65.6	37.5	37.4	48.8	51.4	61.6	25.8	86.7	54.77	
Number of plats averaged.....	2	2	2	2	2	2	2	2	4	3	2	2	.....	

¹Continuous selection since 1903.

TABLE 16—Weight per bushel of crop harvested from light and heavy seed of Kherson oats as separated by a fanning mill, 1905 to 1916

Kind of seed planted	1905	1906	1907	1908	1909	1910	1911	1912	1913	1914	1915	1916	Average
	Lbs. (2)	Lbs. (3)	Lbs. (4)	Lbs. (5)	Lbs. (6)	Lbs. (7)	Lbs. (8)	Lbs. (9)	Lbs. (10)	Lbs. (11)	Lbs. (12)	Lbs. (13)	Pounds (14)
Original unselected.....		35.0	29.2	23.2	26.5	31.0	34.0	25.0	28.5	23.2	21.2	30.0	27.9
Heaviest one-fourth.....		35.0	29.6	24.5	26.5	31.0	34.0	25.0	26.8	25.7	24.0	33.0	28.6
Lightest one-fourth.....		34.5	28.5	24.5	26.2	31.0	34.0	24.0	26.3	23.5	20.5	31.5	27.7

TABLE 17—Yields of light and heavy seed of American Banner oats as separated by a fanning mill, 1909 to 1916

Kind of seed planted	Yield per acre									
	1909	1910	1911	1912	1913	1914	1915	1916	Av. for 8 years	Av. last 4 years
(1)	Bushels (2)	Bushels (3)	Bushels (4)	Bushels (5)	Bushels (6)	Bushels (7)	Bushels (8)	Bushels (9)	Bushels (10)	Bushels (11)
Original unselected	58.8	47.9	35.4	32.8	30.0	45.4	22.1	69.6	41.70	41.77
Heaviest one-fourth	58.2	50.2	29.8	33.3	29.7	39.0	24.2	65.8	43.14	39.70
Lightest one-fourth					32.3	45.7	21.1	74.5		43.40
Number of plats averaged	2	2	2	2	4	3	2	2		

TABLE 18—Weight per bushel of crop harvested from light and heavy seed of American Banner oats as separated by a fanning mill, 1909 to 1916

Kind of seed planted	1909	1910	1911	1912	1913	1914	1915	1916	Av. for 8 years	Av. last 4 years
	Pounds (2)	Pounds (3)	Pounds (4)	Pounds (5)	Pounds (6)	Pounds (7)	Pounds (8)	Pounds (9)	Pounds (10)	Pounds (11)
(1)										
Original unselected	21.5	31.5	26.5	22.0	27.5	26.2	21.2	31.0	26.0	26.5
Heaviest one-fourth	28.2	31.5	23.5	22.0	28.0	20.7	19.5	30.0	26.0	24.5
Lightest one-fourth					27.7	23.0	20.7	30.7	25.9	25.5

crop previously grown from the heaviest one-fourth seed. This has given an opportunity for an accumulative effect of the use of the fanning mill. As a standard for determining the increase or decrease in yield from the two grades, a crop from the original unselected seed has been grown each season along with that from the selected seed. The results for the two varieties are given in tables 15 to 18.

As an average for 12 years, the heaviest one-fourth Kherson oats seed yielded 0.77 bushel better than the unselected seed, while the light seed yielded 0.09 bushel better. This difference is slight and may be regarded as within the limits of experimental error. The use of the fanning mill had very little effect upon the quality of the crop harvested.

In the 8-year test with American Banner oats, which is a relatively late and unadapted variety, only the light and heavy seed were compared during the first 4 years, while the unselected



Fig. 17—Test plats of light and heavy American Banner seed oats. (1916.)
Left to right: Unselected seed, heaviest one-fourth, lightest one-fourth seed planted

seed was included after 1912. As an 8-year average the light seed has yielded 1.44 bushels more than the heavy. During the last four years, the heavy seed has yielded 2.07 bushels less and the light seed has yielded 1.63 bushels more than the unselected

seed. This variety appears to have been a mixture of strains, before the original separation was made. These were of such a character that they have been separated by the fanning mill. On an average for the last 5 years, the crop from the light seed has ripened 2 days earlier than that from the heavy seed. The lighter weight of the seed planted has evidently been associated with earliness and higher yield in this case. The crop harvested, however, has had slightly greater weight per bushel from the light seed.

These experiments indicate that little practical improvement in the yield of oats may be effected by planting only the heavy grade of seed as may be obtained from the use of a fanning mill. In general, the fanning mill is not a grain breeder. Its practical use consists largely in removing trash and weed seed when present in the seed.

EQUAL WEIGHTS VERSUS EQUAL NUMBERS OF LARGE AND SMALL OATS SEED

During 5 years, 1912 to 1916, large and small hand-selected seeds of Kherson oats have been compared for yield at the normal rate of planting. The plan has been to plant the grades in both equal numbers and equal weights at an optimum rate for the large seeds. The various rates have been grown in series of nursery plats repeated ten times. The results are given in table 19.

When planted in equal numbers, the small seed yielded only 89 per cent as much as the large, while both grades yielded equally when equal weights of seed were used. The difference of 2 per cent in yield between the two grades and the unselected seed is within the limits of experimental error. Planting equal weights of the different grades corresponds more nearly to what would happen in farm practice than does planting equal numbers.

RATE OF PLANTING

Rate-planting tests with oats have been made since 1903. Since the various rates have not all been tested thruout the entire period, the results have been grouped in a number of tables (tables 20 to 24) according to the duration of the test. Well-cleaned oats have been drilled each year in duplicate or triplicate plats of 1-30 to 1-15 acre area.

In a 12-year comparison of 8 and 16 pecks of Kherson oats per acre, the 16 pecks have given a 2.1-bushel greater yield and a 0.1-bushel greater net return. By net return is meant the yield per acre less the amount of seed planted.

During a 9-year period, 8 and 16 pecks per acre have yielded respectively 4.2 and 8.2 bushels more than a 4-peck seeding, while the net returns have been 3.2 and 5.2 bushels greater.

In an 8-year comparison, 8, 10, 12, and 16 pecks of Kherson oats per acre have yielded respectively 61.9, 61.6, 62.4, and 63.4 bushels, while the net returns were 59.9, 59.1, 59.4, and 59.4 bushels.

TABLE 19—Yields from equal numbers versus equal weights of large and small seed of Kherson oats, 1912 to 1916 ¹

Kind of seed planted	Equal numbers of seed			Equal weights of seed		
	Seed per acre		Yield per acre	Seed per acre		Yield per acre
	Number	Weight		Number	Weight	
(1)	(2)	Pounds (3)	Bushels (4)	(5)	Pounds (6)	Bushels (7)
YEAR 1912						
Large.....	1,319,868	73	25.4	1,319,868	73	25.4
Small.....	1,319,868	50	23.8	1,897,729	73	23.6
Unselected.....				1,633,500	73	24.7
YEAR 1913						
Large.....	1,319,868	64	71.5	1,319,868	64	71.5
Small.....	1,319,868	34	55.1	2,450,250	64	76.3
Unselected.....				1,767,447	64	72.0
YEAR 1914						
Large.....	1,319,868	55	26.5	1,319,868	55	26.5
Small.....	1,319,868	35	27.0	2,100,681	55	24.7
Unselected.....				1,653,102	55	25.0
YEAR 1915						
Large.....	1,306,800	65	34.0	1,306,800	65	34.0
Small.....	1,306,800	35	33.3	2,479,653	65	38.2
Unselected.....				1,731,510	65	36.0
YEAR 1916						
Large.....	1,306,800	61	73.8	1,306,800	61	73.3
Small.....	1,306,800	28	65.5	2,868,426	61	67.9
Unselected.....				2,041,875	61	68.8
FIVE YEAR AVERAGE						
Large.....	1,314,641	64	46.1	1,314,641	64	46.1
Small.....	1,314,641	36	40.9	2,359,348	64	46.1
Unselected.....				1,765,487	64	45.3

¹The tests were made in single row plats in 1912 and 1913 and in 3-row blocks in 1914, 1915 and 1916. Results are based on the center row of three-row blocks.

All tests were replicated ten times each year, except the unselected seed, which was repeated 30 times.

During the 4-year period, 1913 to 1916, Kherson oats were grown at six rates of seeding, namely, 4, 8, 10, 12, 14, and 16 pecks per acre. The average yields for these rates were respec-

TABLE 20—*Rate of planting Kherson oats (12 years)*

Rate per acre	Yield per acre													Net return
	1903	1905	1906	1907	1908	1909	1910	1912	1913	1914	1915	1916	Av'ge	Net return
<i>Pcks</i>	<i>Bu.</i>	<i>Bu.</i>	<i>Bu.</i>	<i>Bu.</i>	<i>Bu.</i>	<i>Bu.</i>	<i>Bu.</i>	<i>Bu.</i>	<i>Bu.</i>	<i>Bu.</i>	<i>Bu.</i>	<i>Bu.</i>	<i>Bu.</i>	<i>Bushels</i>
8.....	63.7	86.1	67.1	51.4	48.3	56.4	36.9	49.7	55.2	59.7	29.6	82.2	57.2	55.2
16.....	64.2	76.9	64.1	50.5	56.4	59.4	43.6	44.8	49.4	69.1	40.3	92.6	59.3	55.3

TABLE 21—*Rate of planting Kherson oats (9 years)*

Rate per acre	Yield per acre										Net return
	1907	1908	1909	1910	1912	1913	1914	1915	1916	Average	Net return
<i>Pcks</i>	<i>Bushels</i>	<i>Bushels</i>	<i>Bushels</i>	<i>Bushels</i>	<i>Bushels</i>	<i>Bushels</i>	<i>Bushels</i>	<i>Bushels</i>	<i>Bushels</i>	<i>Bushels</i>	<i>Bushels</i>
4.....	44.5	37.8	50.5	33.4	44.1	52.2	58.0	35.7	75.7	48.0	47.0
8.....	51.4	48.3	56.4	36.9	49.7	55.2	59.7	29.6	82.2	52.2	50.2
16.....	50.5	56.4	59.4	43.6	44.8	49.4	69.1	40.3	92.6	56.2	52.2

TABLE 22—*Rate of planting Kherson oats (8 years)*

Rate per acre	Yield per acre									Net return
	1903	1905	1906	1907	1913	1914	1915	1916	Average	Net return
<i>Pcks</i>	<i>Bushels</i>	<i>Bushels</i>	<i>Bushels</i>	<i>Bushels</i>	<i>Bushels</i>	<i>Bushels</i>	<i>Bushels</i>	<i>Bushels</i>	<i>Bushels</i>	<i>Bushels</i>
8.....	63.7	86.1	67.1	51.4	55.2	59.7	29.6	82.2	61.9	59.9
10.....	55.9	81.2	66.5	48.2	56.1	65.5	34.7	84.6	61.6	59.1
12.....	58.7	80.4	66.2	51.2	50.6	66.4	40.3	85.1	62.4	59.4
16.....	64.2	76.9	64.1	50.5	49.4	69.1	40.3	92.6	63.4	59.4

tively 55.4, 56.7, 60.2, 60.6, 61.2, and 62.9 bushels per acre. The respective net returns were 54.4, 54.7, 57.7, 57.6, 57.7, and 58.9 bushels per acre. Both the maximum yield and maximum net return were secured from the 4-bushel rate of seeding. The yield was distinctly better from a 10-peck than from a lighter rate, while the differences between the 10 pecks and the higher rates were very slight.

TABLE 23—*Rate of planting Kherson oats, 1913 to 1916*

Rate per acre	Yield per acre					
	1913	1914	1915	1916	Average	Net return
<i>Pecks</i>	<i>Bushels</i>	<i>Bushels</i>	<i>Bushels</i>	<i>Bushels</i>	<i>Bushels</i>	<i>Bushels</i>
4.....	52.2	58.0	35.7	75.7	55.4	54.4
8.....	56.2	59.7	29.6	82.2	56.7	54.7
10.....	56.1	65.5	34.7	84.6	60.2	57.7
12.....	50.6	66.4	40.3	85.1	60.6	57.6
14.....	51.5	67.9	39.4	85.8	61.2	57.7
16.....	49.4	69.1	40.3	92.6	62.9	58.9

TABLE 24—*Rate of planting Swedish Select oats, 1913 to 1916*

Rate per acre	Yield per acre					
	1913	1914	1915	1916	Average	Net return
<i>Pecks</i>	<i>Bushels</i>	<i>Bushels</i>	<i>Bushels</i>	<i>Bushels</i>	<i>Bushels</i>	<i>Bushels</i>
4.....	22.1	37.9	23.5	50.1	33.4	32.4
8.....	30.3	43.4	21.1	59.7	38.6	36.6
10.....	29.6	42.8	27.2	63.1	40.7	38.2
12.....	29.1	45.1	29.3	67.5	42.8	39.8
14.....	28.9	46.8	27.2	70.3	43.3	39.8
16.....	27.5	43.7	25.8	73.3	42.6	38.6

All of the data suggest that there may be a rather wide range in rate of planting oats without a material effect upon the net returns per acre. However, each of the four preceding tables indicates that 16 pecks per acre have yielded more than 8 pecks, and the net return is also shown to be greater in three tables. The most practical rate for Kherson oats would seem to be 10 to 12 pecks per acre for conditions comparable with those at the Experiment Station. Under similar conditions, the large seeded varieties, such as Swedish Select, should be planted not thinner than 12 pecks. These rates conform to present general farm practice in eastern Nebraska. It is customary to seed less in central and western Nebraska because of a more probable short-

age of soil moisture. With Swedish Select oats (table 24), which is a larger grain type, identical net returns were secured during a 4-year period from 12 and 14 peck seedings, while the yields were lower for both lighter and heavier rates.

RELATIVE YIELDS OF OATS AND OTHER CROPS AT THE NEBRASKA EXPERIMENT STATION

The relative yields for corn, winter wheat and oats, during the 15-year period, 1902 to 1916, are given in table 25. The relative yields for these crops together with spring wheat are also shown for the 8-year period, 1909 to 1915.

TABLE 25—*Relative yields of oats and other crops at the Nebraska Experiment Station, 1902 to 1915*

Year	Kherson oats	Hogue's Yellow Dent corn	Turkey Red winter wheat	Spring wheat
	<i>Bushels</i>	<i>Bushels</i>	<i>Bushels</i>	<i>Bushels</i>
1902	42	75	33	.....
1903	68	75	32	.....
1904	55	62	18	.....
1905	83	72	21	.....
1906	36	66	62	.....
1907	49	66	52	.....
1908	54	55	38	.....
7-year average	55	67	37	.....
1909	67	41	27	18
1910	42	58	48	30
1911	38	43	51	16
1912	37	48	9	14
1913	45	8	50	17
1914	68	53	34	17
1915	33	75	30	16
1916	85	62	38	22
8-year average	52	48	36	19
15-year average	53	58	36	.....

GENERAL NOTES ON OATS GROWING

1 *Soil Fertility*—One reason for the unsatisfactory yields of oats in recent years in eastern Nebraska is the lessened available fertility, due to continuous grain cropping without a legume, such as alfalfa or clover, in the rotation. Oats also respond favorably to an occasional light application of manure. Increased available fertility and more thoro seed bed preparation add

materially to the yield and profit from growing oats. This fact is illustrated in table 3, in which the yield and the acre income of oats on the Experiment Station farm are compared with the average yield and acre income for Lancaster County. The differences are largely a matter of soil fertility and tillage methods. Early varieties of oats grow on reasonably productive soils without serious lodging.

2 *The Seed Bed*—In general, oats should be planted upon cornstalk land. The seed bed should be prepared either by thoro double-disking and harrowing, or by shallow plowing followed by thoro diskling and harrowing. Early preparation is desirable.

A comparison of different methods of seed bed preparation and of crop sequence has been made by the Experimental Substation at North Platte, during a period of 8 years, 1907 to 1914. The results are given in table 26. Slightly lower yields

TABLE 26—Yield of oats, spring wheat, and barley from different seed bed preparation and crop sequences. Average, 1907 to 1914¹

Preparation of seed bed	Previous crop	Yield per acre		
		Oats	Spring wheat	Barley
Fall plowed	Corn	<i>Bushels</i>	<i>Bushels</i>	<i>Bushels</i>
	Oats	20.7	12.0	11.1
	Wheat		11.7	
	Spring wheat	17.1		
	Barley	15.4		17.1
	Average	17.7	11.6	
Spring plowed	Corn	19.6	10.2	
	Oats	16.3	9.6	15.9
	Wheat		12.2	
	Spring wheat	19.4		
	Barley			15.8
	Sorghum	16.5	10.1	
Disked	Average	18.5	10.6	15.9
	Corn	17.9	10.4	13.4

¹Compiled from Nebraska North Platte Substation Bulletin No. 17.

are indicated for oats, barley, and spring wheat from diskling than from either spring or fall plowing. The lower cost of seed bed preparation by diskling makes this method somewhat more profitable, however.

In eastern Nebraska, shallow plowing and thoro double-disking are regarded as equally profitable. However, where a large acreage is to be seeded, disking will prove most practical, since the land can be prepared more quickly, thus permitting earlier seeding.

3 *Choice of Seed*—Early varieties give best results in the average year thruout most of the State. Nebraska No. 21 oats and Burt oats surpass other varieties but are not yet available in large amounts commercially. The common Kherson oats is the best variety that may be secured in large quantities at the present time. Local conditions of soil and climate may, however, make the planting of other varieties desirable. While Kherson and the other early oats are suited especially to fertile soil and to general Nebraska conditions, it may be advisable to select a larger and later variety for the poorer soils of the northern part of the State.

4 *Preparation of Seed*—Grading or fanning the seed need be practiced only to remove weed seeds and trash when these are present, and in occasional years to remove immature seeds.

Treatment to prevent smut is desirable, unless it is positively known that the field in which the seed had been grown was free from smut. The smut is carried over from one crop to the next on the exterior of the seed. This may be prevented by the formalin treatment as follows: Add commercial formalin (40 per cent solution of formaldehyde) to water in the proportion of 1 pound to 40 gallons of water. If made too strong, the viability of the seed will be impaired. Pile the seed upon a granary floor or similar place. Apply the formalin solution at the rate of about 3 quarts to 1 bushel of seed. During the application the pile should be thoroly scooped in order to dampen all the seed. Then cover the seed with empty bags or blankets for several hours or over night. Uncover and spread the oats out thin, and dry rapidly, stirring them occasionally. Replacing them in bags or other containers infested with oats smut should be avoided. Infected sacks may be used after being dipped into the formaldehyde solution and dried. It may be necessary to adjust the rate of planting to allow for swelling of the seed caused by the moisture.

If sown with an end-gate seeder, the oats need not be dried before seeding, altho with a grain drill this is necessary since damp oats do not feed well thru a drill.

5 *Seeding*—Oats may be sown either broadcast or with a drill. The customary farm practice in eastern Nebraska is to seed oats and other spring small grain crops broadcast. Whether this practice can be followed with profit, however, depends largely upon soil and climatic conditions, while drilling is a more standard method and can always be used safely. Table 27 contains yields

TABLE 27—Yields from drilled and broadcast oats, spring wheat, barley, emmer, and winter wheat. Four-year average¹

Method of planting	North Platte data (4-year average)					Lincoln data (4-yr. av.)	
	Oats	Spring wheat	Barley	Emmer	Winter wheat	Oats	Winter wheat
	<i>Bushels</i>	<i>Bushels</i>	<i>Bushels</i>	<i>Bushels</i>	<i>Bushels</i>	<i>Bushels</i>	<i>Bushels</i>
Drilled	40.1	16.3	16.5	35.0	20.6	57.9	38.2
Broadcast	31.4	10.5	9.2	26.1	9.7	58.8	38.2
Increase from drilling	8.7	5.8	7.3	8.9	10.9	— .9	.0

¹Data compiled from Nebraska North Platte Substation Bulletin No. 12, were secured in 1908, 1909, 1911 and 1913. The data compiled from Nebraska Bulletin No. 104 were secured in 1900, 1903, 1905 and 1906.

²Three-year average.

secured both at North Platte and Lincoln, for the two methods of seeding.

Drilling has proved much superior under the conditions at North Platte, whereas the yields were approximately equal for the two methods at Lincoln. It is reasonable that drilling should be relatively more favorable in the central and western parts of the State where soil moisture conditions are commonly less favorable for early growth. Oats planted with a press drill are placed uniformly in a more moist and more compact soil than is the case with broadcasting, and this gives a more certain and uniform germination.

These considerations are not so important under the more favorable moisture conditions of eastern Nebraska. The better the seed bed preparation and the more favorable the soil moisture conditions, the smaller will be the difference in yield between drilled and broadcast oats.

The most satisfactory rate of planting small seeded varieties is 2.5 to 3 bushels per acre for eastern Nebraska. Three bushels per acre is a very satisfactory rate for varieties having large seeds. These amounts may be somewhat reduced in central and western Nebraska, because of less favorable moisture conditions.

6 *Harvesting*—If the oats straw is to be used for feed, the crop should be harvested a day or two before being fully ripe, and while the straw is still slightly green. In order to insure the best quality of grain and the highest feeding value of the straw, the crop should be stacked as soon as the oats are dried out after cutting and shocking. The shape of the shock is also of more or less importance. If the oats straw is green when harvested or if large weeds are abundant or if the weather is not favorable for drying, the long type of shock is best. Otherwise, the ordinary round shock is satisfactory. The long shocks should usually be built north and south as this protects the bundles somewhat from

heavy rains, and exposes both sides of the shock to the sun and wind. Another important factor is to carefully stack the straw pile, as oat straw makes very good feed.

SUBSTITUTE CROPS FOR OATS

Spring Wheat—Spring wheat and spring barley are the two most satisfactory substitute crops for oats. Spring wheat should commonly be seeded before oats, and as early as the soil can be worked in the spring. The most satisfactory practice is to drill in fall plowed land or on disked corn ground. The usual rate of seeding is 6 pecks per acre for the eastern part of the state and 4 pecks for the western part. This crop is poorly adapted to the climatic conditions of the greater part of Nebraska because of late maturity, and it is far more subject to drouth, heat, rust, and chinch bugs than is winter wheat. At Lincoln spring wheat has produced approximately only half as great yields as winter wheat.

Table 28 contains the results with eight varieties of spring wheat tested from 3 to 6 years in duplicate 1/30-acre field plats.

The spring wheat varieties now grown in this State under the names of Swedish, Scotch Fife, and Early Java are probably the best suited for the greater portion of the State. Altho Marquis wheat, imported in 1911 from Canada, has given a slightly higher yield at the Experiment Station, the quality of grain has been somewhat inferior because of excessive shriveling with consequent light weight per bushel. The 6-year average for the three highest yielding varieties of spring wheat has been 17.1 bushels or 1,026 pounds per acre, as compared with 55.5 bushels or 1,776 pounds for Kherson oats.

Barley—Experience has taught that varieties of the bearded 6-row type of spring barley yield most in our climate. The common 6-row barley, Oderbrucker, Odessa, and Manchurian are of this type.

Barley is not so easily damaged by heat and dry weather as are oats, and for this reason it is customary to seed this crop immediately after oats planting. The method of seed bed preparation and of planting are essentially the same as for oats and spring wheat. The ordinary rate of seeding in eastern Nebraska is about 2 bushels per acre. The rate recommended for the drier sections of the state is 1.5 to 2 bushels.

The relative yields of barley, oats, and several other small grain crops during the 4-year period, 1907 to 1910, are given in table 29. Kherson oats yielded 20 per cent less grain than Oderbrucker barley, while Turkey Red winter wheat yielded 20 per

TABLE 28—Yield test of spring wheat varieties, 1911 to 1916

Variety	Yield per acre						
	1911	1912	1913	1914	1915	1916	Average 1912 to 1916
	<i>Bushels</i>	<i>Bushels</i>	<i>Bushels</i>	<i>Bushels</i>	<i>Bushels</i>	<i>Bushels</i>	<i>Bushels</i>
Scotch Fife.....	16.8	12.1	16.9	15.0	17.8	21.6	18.1
Marquis.....	15.6	13.8	17.4	17.4	16.5	23.3	19.1
Swedish.....	.....	14.2	17.2	15.1	15.9	22.0	17.7
Early Java (Minnesota).....	.....	.....	.....	14.1	16.6	18.8	16.5
Red Spring.....	.....	.....	.....	14.7	17.0	20.1	17.3
Early Java (Nebraska).....	.....	.....	.....	15.4	16.0	21.6	17.7
Roggenbach.....	.....	.....	.....	14.1	15.7	20.5	16.8
Early Spring.....	.....	.....	.....	7.3	11.8	17.3	12.1
Kherson oats.....	38.5	37.4	44.8	69.7	40.1	85.4	65.1

TABLE 29—Relative yields of various small grain crops. Average, 1907 to 1910

	Average date ripe 1907-1908	Yield per acre			
		1907	1908	1909	1910
		<i>Bushels</i>	<i>Bushels</i>	<i>Bushels</i>	<i>Bushels</i>
					<i>Pounds</i>
Kherson oats.....	July 14	48.0	55.7	56.5	44.8
Winter oats.....	.....	.....	57.8	0.0	0.0
Spring barley (Oderbrucker).....	July 16	41.1	39.6	44.3	46.6
Winter barley (Tennessee).....	June 29	68.0	49.4	0.0	0.0
Black winter emmer.....	.....	.....	47.7	0.0	41.7
Turkey Red winter wheat.....	July 3	52.0	38.0	27.0	48.0
Winter rye.....	July 1	66.0	44.1	.....	31.9

cent more. Altho barley gives a greater grain yield, oats straw has a greater value than barley straw, and the crop is also much more pleasant to handle during harvest and threshing. The oats grain also has a special feeding value for horses.

Winter Oats—Winter oats have proved unhardy and in most seasons have entirely winterkilled.

Winter Barley—Winter barley also lacks in hardiness, and for this reason it is an unsafe and unsatisfactory crop. In those years when it survives the winter, it ripens two weeks earlier than common barley and yields considerably more. The development of a hardy strain of winter barley would doubtless be a valuable achievement. In 1910, only 220 plants survived on a $\frac{1}{4}$ acre plat of winter barley. It was thought that these plants had perhaps survived because of special hardiness. Consequently, they were harvested individually and planted in separate nursery rows for the purpose of further selection for hardiness. A good growth was secured in the fall, but every plant winterkilled. Sufficient seed had been retained from each plant for seeding a second time in the fall of 1911. This again entirely winterkilled.

Winter Emmer—This crop has proved to be less hardy than Turkey Red winter wheat and its value in Nebraska is doubtful. The method of planting is the same as for winter wheat, except the rate of planting, which should be about 2 bushels per acre.





